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Pictorial

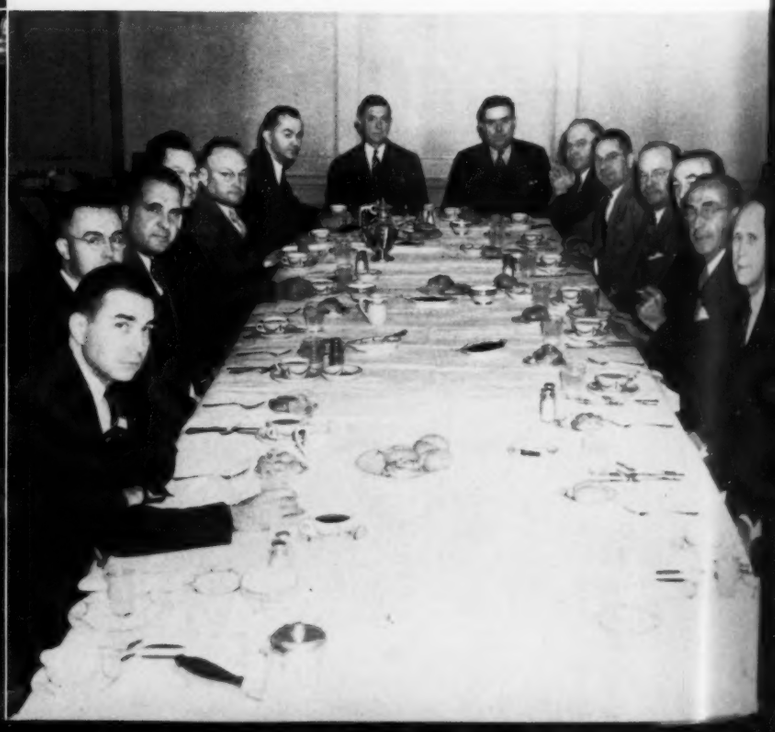
35TH ANNUAL IRON *and* STEEL

Following a three-fold theme of new developments, improved quality and rehabilitation, the thirty-fifth annual Convention and Exposition of the Association of Iron and Steel Engineers rode the crest of a virtual flood of expansion in steel plant operations. With this sudden rush to expand operations placing a heavy burden on the steel plant personnel, the heavy registration and attendance of these men well attest to the importance and value which they attach to the Convention and Exposition.

Among the 6000 members and guests registering at the Convention, J. B. Sullivan and J. J. Bangert (left, top) were early arrivals.

Each morning a conference breakfast (below) for the chairman and authors provided an opportunity for discussing the schedule of the day, so that the various activities might progress smoothly.

At the left, center, are shown the participants in the mechanical session held Tuesday afternoon: A. R. Schulze, G. L. Danforth, Jr., C. J. Duby (chairman), and Stephen Badlam.



Review of CONVENTION *and* EXPOSITION

The Iron and Steel Exposition, composed of the exhibits of 100 manufacturers of steel plant equipment and supplies, was, as usual, the outstanding activity of the Convention. Exhibits were of high quality and displays were arresting. General comment held it to be one of the most attractive Expositions ever staged, and of vital interest to the visitors. The success of the Exposition and other Convention activities is adequately indicated by the total attendance of 14,000.

At right, bottom, is shown L. A. Umansky and Lorenz Iversen as they toured the Exposition, a general view of which is shown on the opposite page.

A feature of Tuesday's program was the electrical session under the chairmanship of W. A. Perry, at which three papers were read by W. B. Skinkle (right, top), D. I. Bohn (right, center), and H. L. Palmer (below).

Always a live subject, the welding meeting on Tuesday afternoon was well attended. Among the authors at this session were Wray Dudley (left, top) who also acted as chairman, J. H. Deppeler (left, center), and J. C. Hodge (left, bottom).

One of the best received features on the program was the symposium on preparation of steel for subsequent rolling, held Wednesday morning, under the leadership of W. C. McConnell and H. G. R. Bennett (above).

This meeting included papers by A. P. Spooner (below), G. W. Lentz, G. D. Winlack, and A. Rousseau (opposite page, left, top, center and bottom respectively). An active discussion followed the papers.

More than seven hundred members and guests took part in the inspection trip Wednesday afternoon to the modern Irvin works of Carnegie-Illinois Steel Corporation. On the opposite page, right, are shown L. L. Hill, David Blair, and J. M. Kelly (top); W. H. Burr and R. J. Wean (center); and at the bottom a meeting of the brothers, F. W. Lorig and E. T. Lorig.

On the opposite page are additional photographs taken on the Irvin works trip, showing T. B. McElray, F. W. Cramer, and J. L. Miller (left, top); Louis Moses, L. F. Coffin, and L. J. Gould (left, center); and James Farrington, and others, (left, bottom).

At the electrical session of Thursday morning, led by L. R. Milburn and K. E. Dinius (opposite page, right, center), three very interesting papers, all applying to various electrical phases of the modern strip mill, were presented by F. Mohler (opposite page, right, bottom), A. F. Kenyon (above), and C. B. Crockett (below).

The combustion session, under the chairmanship of G. M. Coughlin (right, top), presented a varied program of wide interest to fuel men in the industry. Participating in this meeting were J. P. Bankson (right, center), and E. E. Callinan (right, bottom).

Also among the authors taking part in the combustion session were Gilbert Soler (left, top), and G. M. Arnold (left, center).

The operating practice session, in which coke oven and blast furnace subjects were presented, probably produced the most active discussion of any of the technical meetings. This session was capably handled by J. G. West, Jr., and A. H. Fosdick (left, bottom), and included a paper on coke plant yields by J. D. Davis (above), and papers on various phases of blast furnace design and construction by Hjalmar W. Johnson (below) and by L. J. Gould (opposite page, upper left).

An ever-popular topic is that of lubrication, and in this session, headed by T. R. Moxley and F. L. Gray (below), three very interesting papers were read and discussed. The authors for this session were F. J. Thomas (right, top), C. C. Pecu (right, center), and J. H. Jones (right, bottom).

An interesting fact concerning the 1939 Convention and Exposition, and commented on by many, was the unusually serious attitude on the part of the attending steel plant men. Faced with the problems accompanying the rapid expansion of operations, they eagerly sought the help to be derived from the technical papers and the equipment displays forming the Convention activities.

Climaxing the social side of the Convention, a formal banquet and dance was held Thursday night with more than 600 in attendance. Due to the fact that all available space in the Wm. Penn Hotel was taken up by other activities of the Convention, it was necessary to hold the banquet in the main lobby which was effectively screened off for privacy. President C. C. Wales (upper right) acted as toastmaster, and introduced President-elect J. A. Clauss (upper left). The main address of the evening was delivered by B. F. Fairless, who is shown (opposite page, upper left) discussing old times with J. D. Donovan. Mr. Fairless' address was broadcast through station KDKA of the National Broadcasting Company. Following the banquet, a dance was held in the Cardinal Room.

It was announced by the Board of Directors that the 1940 Convention and Exposition will be held at the Hotel Stevens, Chicago, Illinois, September 24, 25, 26, and 27, 1940.

On Friday morning an inspection trip was made by about 300 individuals to the Carnegie-Illinois Steel Corporation's Edgar Thomson works, one of the older important units of the corporation. The trip, covering the greater part of the plant, was well planned through the efforts of H. L. Brindle, shown right, center with Thomas Backus, and John Lloyd, shown right, top, with L. V. Black. At right, bottom, A. J. Diefenderfer explains some of the points of the new slabbing mill at Edgar Thomson works, which supplies slabs to the Irvin plant, to T. E. Dodds.

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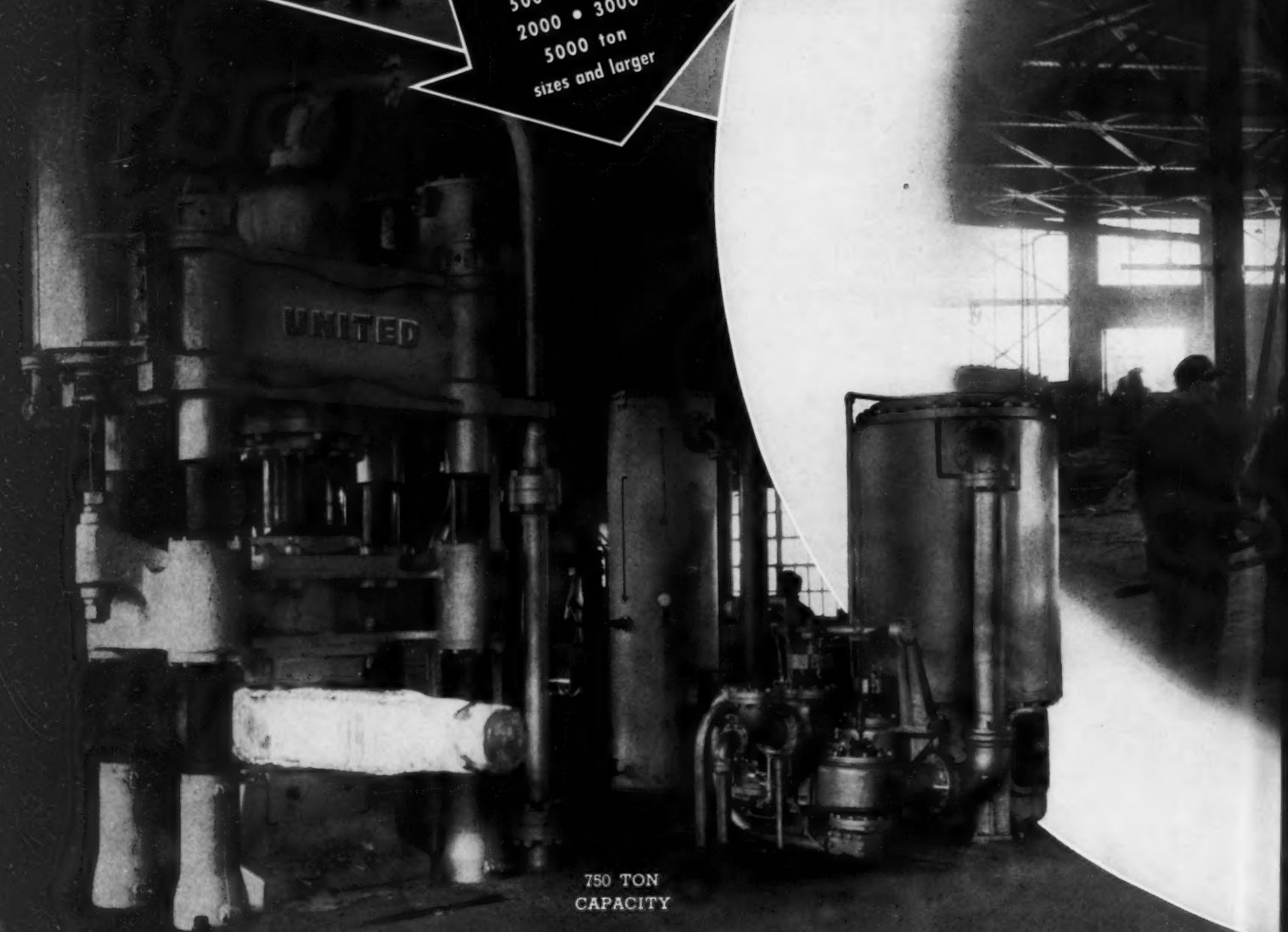

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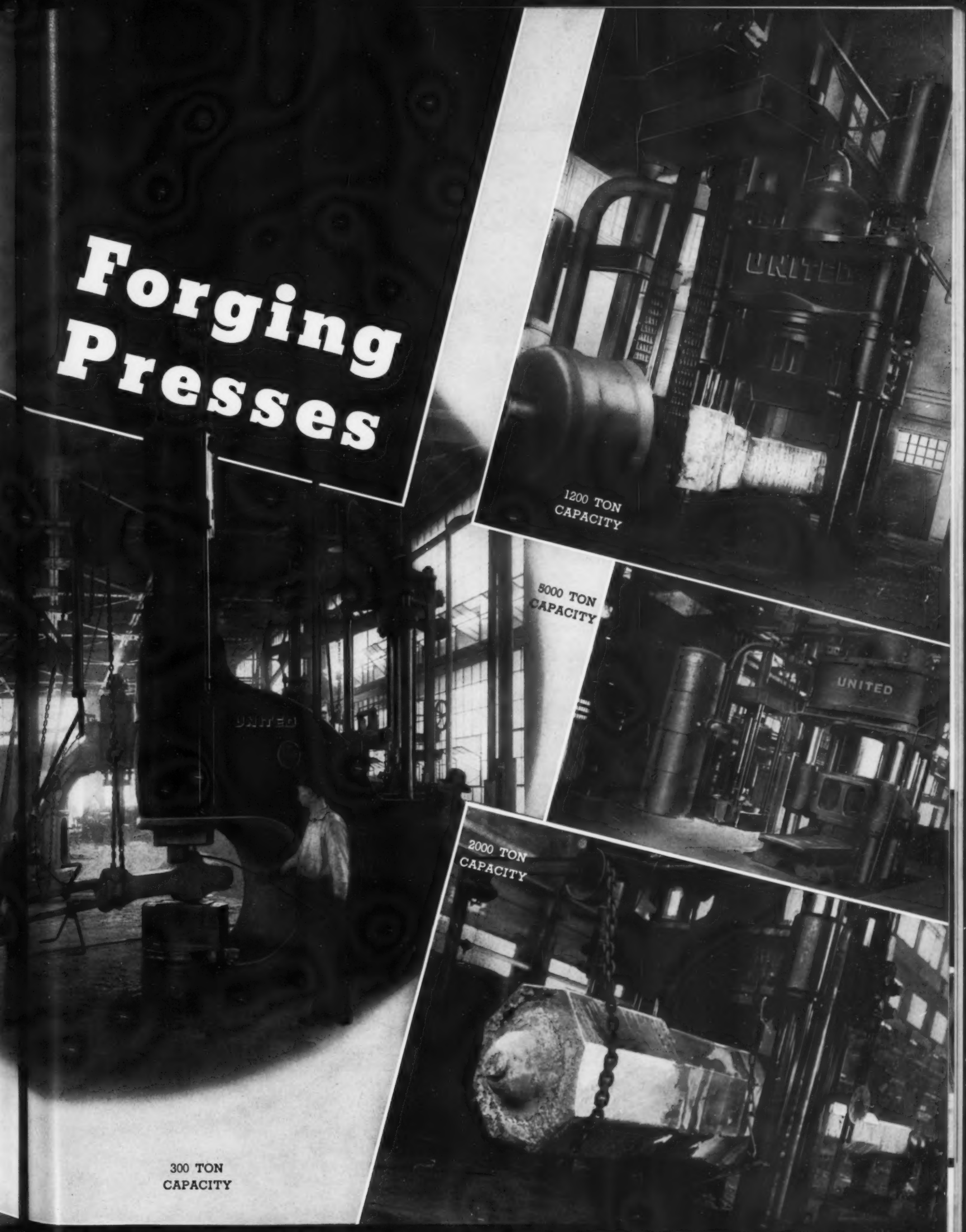

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MODERN *Wire Drawing* PRACTICE

By J. J. PHIFER, *Superintendent*, Wire Works,

Tennessee Coal, Iron & Railroad Company,

Fairfield, Alabama

Presented before A. I. & S. E. Annual Spring Conference, Birmingham, Alabama, March 27-28, 1939.

▲ BY definition, wire is a ductile material drawn to a definite size and form through a die, as distinguished from bars or shapes which are hot or cold rolled or forged to finished dimensions. Wire may be round, square, or any one of a thousand or more special shapes which are drawn to customer's specifications through built-up dies. Our discussion for the most part, however, will be confined to round, low carbon steel wire, drawn from the hot rolled rod by either of two types of wire drawing blocks, intermittent and continuous.

It might be in order at this time to repeat the saying that wire workers feel, "Our civilization is held together by wire."

A maze of statistical figures is often tiresome, but it is of interest to note the following:

General view of an installation of modern continuous wire drawing machines in a large southern mill.

On the average for the last few years, approximately two million tons of plain iron and steel wire were produced in the United States. Nails, which are a product of wire, accounted for 475,000 tons. Not to be disregarded over the same period were two items, consisting of a mere 7,500 tons for coat hangers and 23,000 tons of wire woven into fly screening. Non-ferrous wire, such as copper, brass and bronze accounted for an additional 250,000 tons.

From the above figures, one cannot help but realize that the industry serves a rather large and diversified market for wire and wire products.

While the basic principles of drawing wire have remained unchanged for a century, there has been a steady improvement in the methods and equipment. The real development period in wire drawing machinery took hold in the early twenties. Prior to that time, by far the greater part of steel wire drawing was accomplished by the group driven frame or intermittent method, and, as a matter of fact, a very substantial part of present day tonnage is still being drawn on this type of equipment.

Fundamentally, a wire drawing machine consists of a reel to receive the cleaned and coated rod, a die with suitable lubricant applied to the rod at the point of entry in the die, and a power driven, cylindrical block which acts as a capstan to draw the wire through the die and to provide storage for the finished bundle. Means are provided for pointing the starting end of the rod, and for starting this end through the die and attaching it to the block. Early wire drawing installations, consisting of a series of these blocks driven from a common lineshaft, hold to the original idea of drawing one draft at a time. After each draft, the wire is returned to the starting position and drawn again and again through progressively smaller dies until the desired size is attained.

When starting with a 5 gauge rod, generally speaking, two drafts are required to produce a 9 or 10 gauge wire,

Single block machine used largely for drawing rod for bolt stock, and driven by a 50 hp. adjustable speed motor.

four drafts for 12½ gauge and six drafts for 16—16½ gauge, the reduction in area at each draft ranging from 25-40 per cent.

The various spindles of the group driven type of equipment are usually driven at fixed speeds, and the individual wire drawing blocks are engaged with these vertical spindles by means of the jaw type clutches. In operation, the jaws on the block are lifted free from the driver to stop, and, conversely, dropped on to the driver to start. The start is abrupt and at a fixed speed. Because of the abrupt start, wire drawing speeds and reductions with this type of equipment are limited to what can be started without breakage of the wire. The speeds, being fixed, are necessarily limited to the maximum that can be used for the heaviest work; this, of course, results in a penalty in speed on the smaller sizes, but is offset somewhat by increasing the number of spindles given to one wire drawer.

Many attempts have been made to introduce a friction clutch between the spindle and block to ease the shock of this abrupt starting, but difficulties of maintenance and adjustment of such a clutch on a slowly revolving spindle have prevented a wider use of the device.

To overcome some of these disadvantages, to eliminate the laborious handling of the bundle after each intermediate drafting, and to reduce the time spent in pointing and threading up, the continuous wire drawing machine came into being, just as the older methods of rolling flat strip have been supplanted by continuous processes.

Improvement in continuous drawing equipment has been considerably more rapid in copper and its alloys than in steel. Early attempts at continuous drawing, while directed in large part toward removal of slip on the successive drums, was for the most part ineffective. The continuous machines employed in drawing copper and its alloys today are largely slip machines, but due to the nature of the metal and the fact that the lubricant is in solution, less difficulty is presented from slip on the drums than is the case with steel, which is almost entirely drawn in the coarser gauges by what is known as the dry method, entailing the use of lubricants such as soap, grease, tallow, oil, stearates, palmitates and other materials.

Before discussing the various types of continuous equipment, we should mention the single spindle, individually motor driven machine, which has come into general use for drawing the coarser sizes requiring only one or two drafts. With this machine, two drafts may be taken simultaneously on the same spindle by the use of a double deck block.

The diameter of the two blocks on the double deck block are proportioned rather closely to the reduction in area of the wire at the second draft, with a small allowance for slip on the first draft block. Direct current motors are preferred for this type of equipment, to obtain slow draw-in speeds, smooth acceleration, dynamic braking and adjustable speed to meet the varying conditions of stock and drafting required. These machines may be grouped into units of two or more spindles for multiple draft work, and are built in a wide range of sizes.

For wire requiring three or more drafts, several types of machines employing the continuous principle are now available. These fall into two broad general classifications, namely:

(1) Machines with the spindles group driven at

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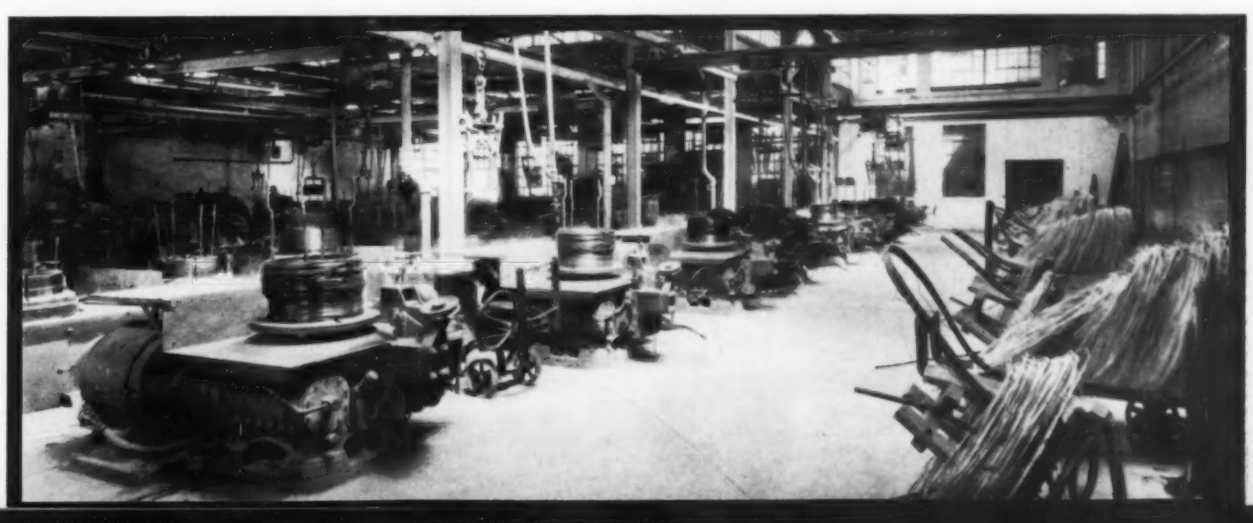
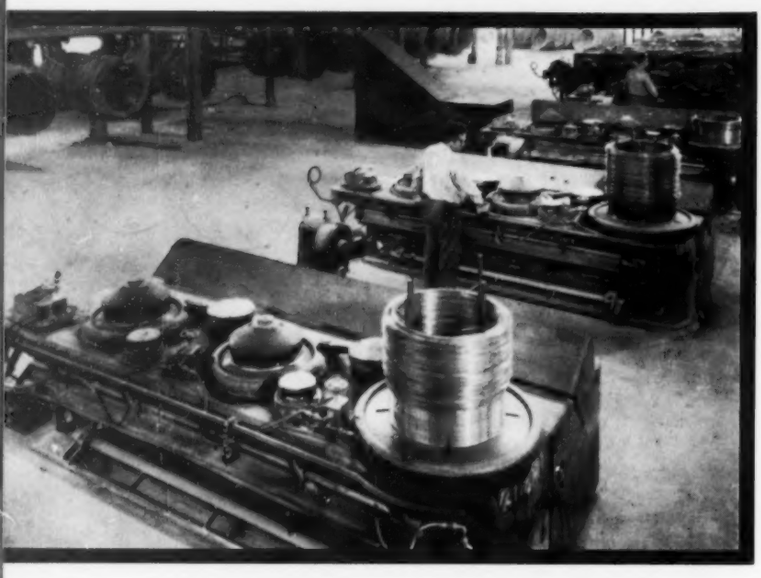
General view of installation of double deck drawing machines in a modern mill.





View of installation of modern continuous machines for drawing 3, 4, 5 and 6 hole steel wire.

fixed speed ratios and powered by a-c. or d-c. motors.

(2) Machines with each spindle driven independently by an adjustable speed motor.

In the fixed speed ratio classification, one type of machine utilizes a spring tensioned sheave between each block, over which a loop of the wire is passed to maintain a tension on the wire on the preceding block. If this block delivers more wire than the block following, this tension is automatically reduced and slippage occurs until the unbalance is corrected. With this type of machine, it is necessary to allow a small percent of slip in the calculations of block speed ratios and drafting practice. Obviously, the drafting has to be held within very close limits, and the speeds will be theoretically correct for only one drafting setup.

A second type of fixed speed ratio equipment accumulates a surplus of wire on each of the intermediate blocks as a reservoir for the following reduction. As the wire is drawn onto the fillet at the bottom of the block, it is taken off at the top and passed over a series of sheaves to the die of the next block. Any unbalance in the drafting results in a gradual increase or decrease in the amount of wire stored on the block. This design permits air-cooling of the wire between each draft, thereby lowering the temperature of the wire and dies, with beneficial results as to surface finish and die life.

A third type of fixed speed ratio equipment has several wire drawing capstans of progressively larger diameter mounted on two parallel spindles, the group on each spindle being in the form of a cone-pulley. In this machine, the wire passes from one step of the cone through a die to the opposite spindle; always to a larger diameter, thus taking up the elongation of the wire by progressively higher speeds. Successful operation of this type of machine requires a certain amount of slippage on the cones, and very careful regulation of the drafting. Its principal application is to wet drawing of fine gauge screen wire, weaving wire, and the various copper coated and liquor finish wires. As many as 10 or 12 reductions are taken on the cones before the wire passes to the finishing draft, which is usually taken on a vertical spindle block. To avoid damage to the coating, the percentage of slip is held to a minimum.

The general principle of continuous wire drawing, as in the continuous rolling mill train, requires that each spindle speed be adjusted to pass the same number of pounds per minute through its die as the preceding draft; otherwise, slippage occurs, or the excess must be stored on the intermediate blocks. Slippage is, of course, always undesirable, as it destroys the coating on the wire and results in scratched wire and shortened die life. It was therefore a logical development to apply individual drives to each of the blocks, and to utilize the wide speed range and close speed regulation available with modern electrical equipment to obtain these very desirable characteristics in a wire drawing machine.

The machines incorporating an individual, adjustable speed motor drive for each spindle permit a wider size range and greater variations in drafting practice, and in general are far more flexible than the machines with fixed speed ratios.

The initial cost of such equipment is, of course, much higher than the fixed speed design, due to the increased amount and complexity of the electrical equipment. This design utilizes a shunt field rheostat to control the speed of each block, each rheostat being regulated from a dancer sheave positioned by a loop in the wire between the blocks. The speed is set on the finishing motor through a hand rheostat, varying with the different sizes, and the balance of the motors in the machine come into adjustment automatically due to the syn-

Modern cone-type machine used mainly for ferrous or non-ferrous wire.

chronization and automatic control of all the motors. Back tension on the wire is provided by adjustable coil springs on the dancer sheave arms. Wire is continually drawn on the same plane without twists, an impossible condition on a storage type machine. The control system on these machines is very sensitive to small changes in the drafting, and slippage is reduced to a minimum.

A double deck block is frequently applied to the roughing or finishing spindle, making an extra draft available for greater flexibility. It is generally considered more satisfactory to use the double deck block on the first draft because of the better condition of coating, and, since the block is never unloaded at this point, the first draft, or smaller diameter block can be placed on top, thus simplifying the threading-up operation.

All of the modern designs incorporate features which have lightened the work of the wire drawer, increased his earnings and made his work safer and more inviting from every angle. Practically all coarse wire drawing equipment now available incorporates the stripper type finishing block, by which the finished bundle is hoisted mechanically from the block, relieving the operator of this back-breaking work. Slow draw-in speeds, smooth acceleration, dynamic braking, and safety stops at every point of danger have reduced the accident hazard.

The newer machines are self-contained units, with all mechanism above the floor level, and therefore require no pits or elaborate foundations. Those of you who have a large amount of underground auxiliary equipment will appreciate the aid to maintenance and good housekeeping which such compact equipment affords.

Regarding general design, the modern wire drawing machine conforms to accepted standards of machine tool design, including the liberal use of anti-friction bearings, precision gearing and automatic lubrication.

By the use of electric butt welding, the size of the finished bundle is now limited only by the capacity of the finishing block, and by its ultimate use in the finishing departments. The use of air and water cooling for dies and blocks, coupled with slow draw-in speeds and smooth acceleration, have made possible a notable increase in drawing speeds.

In the matter of speeds for various machines and sizes, the low carbon range on rod machines and intermediate machines has been gradually moved up to between 1,000 and 1,500 feet per minute. On high carbon over this same range, speeds have been brought up from 200 to 300 feet to from 450 to 1,000 feet per minute. On the finer sizes of low carbon steel wire, speeds from 1,500 to 2,000 and 2,500 feet per minute are being attained. It should be understood that speed limits mentioned are not necessarily the highest that may be attained nor are they always possible of attainment even as noted. Many varying conditions of wire requirements, stocks and cooling, etc., as well as operating conditions and efficiency, will dictate the choice of finishing speeds. Speed alone can never be considered the final answer in the most efficient operation and highest tonnage. But speed, as such, can never be ignored in figuring these items in a proper and modern approach to wire drawing problems.

Multiple operations conserve floor space which is a factor to be considered when over-all installation cost of equipment is being estimated.

Probably the most revolutionary development in wire drawing equipment in recent years has been the cemented tungsten carbide die. A decade ago, the best die available was chilled iron, and a wire drawer expected to draw three or four 160 pound bundles through each die before it was worn beyond the allowable tolerances. Even so, there was a pronounced difference in gauge between the front and back end of each bundle. Today, as much as 30,000 pounds of wire has been drawn through a single die, with starting and finishing sizes well within the specified tolerances. The benefits of such a startling improvement in die life go far beyond the wire mill Surface finish has been improved, the variation in gauge has been greatly minimized, larger bundles can be produced to closer gauge tolerances than ever before. All of these qualities are very acceptable, both to our own finishing departments and to the manufacturing trade.

The trend in wire drawing practice is to higher speeds, heavier bundles, improved surface finish, closer tolerances on gauge, and improved lubricants have done much to make these advances possible. Machines are now in process of development which are designed to draw coarse low carbon wire at 2000 feet per minute. Automatic take-offs which accumulate the finished wire continuously, and to any desired weight of bundle have been developed. Unfortunately, the older mills cannot make full use of this development, as the whole finishing end has to be equipped to handle such heavy bundles.

While this discussion has centered on types of equipment available, you as operating men will understand

Modern 5-block tandem machine used for drawing steel wire, using individual d-c. adjustable speed motors.

that there are many things ahead of the machines which seriously affect the quality of product and resulting productivity of the equipment. The proper rolling and processing, and particularly the cleaning and coating, are vital factors in a successful wire drawing operation.

In conclusion, it is appropriate that we mention the contribution which the steel makers have made toward the advances in wire drawing practice. It is now possible to draw a hot rolled rod six, eight, or even more drafts to about 5 per cent of its original diameter, involving a total reduction in area of 95 per cent, without annealing or other heat treatment in the process.

When it is considered that the actual tension required to draw the wire through each of these drafts is 60 to 80 per cent of its ultimate tensile strength at that draft, you will realize that this is truly an acid test of the soundness and uniformity of the stock. Without such steel, the continuous wire drawing process would be a lamentable failure, and much of the credit for the success of the process can be attributed to the uniformly high quality of our processing billets, and to the men who have brought such properties within the realm of ordinary commercial practice.

DISCUSSION

PRESENTED BY

G. E. STOLTZ, Manager, Metal Working Engineering Section, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

G. E. STOLTZ: On the tandem wire drawing machines using individual motors on each block, the characteristics of the motor are quite important. The motors must all be started and accelerated at the same rate or the amount of slack in the wire between blocks which is equal to twice the travel of the dancer arm, will be used up and result in drawing the dancer arm against its stop which will cause the wire to break.

Since the relative speeds of the various motors are controlled by the position of the dancer arm rheostats, these arms must be effective during the accelerating period as well as when the motors are running continuously.

The motor field must be designed for the maximum speed of response so that the correction is quickly and accurately made. In addition to the shunt field, these motors are supplied with a stabilizing series field which also acts as a damper or anti-hunting device in relation to the shunt field. In other words, the change in position of the dancer arm results in a change in speed of the motor and as is characteristic in all drives that have inertia there is a tendency for the shunt field to overcorrect. The series field on the motor neutralizes part of the shunt field's correction and stabilizes the units and prevents too severe swinging of the dancer arm.

On wire drawing machines using different size motors and operating at different speeds, the amount of series field or the amount of compounding must be adjustable. Therefore, the motors are supplied with a rather heavy series field and the field in turn is equipped with a shunt which can be readily adjusted to give the desired compounding to stabilize the motors.

Safety demands that in case of an emergency, that the motors stop very quickly. It is desirable to stop the motors within one revolution or so of the wire drawing block and this represents a very short period of time. In order to stop the motor in this length of time, it is necessary to apply severe dynamic braking and also to adjust the dynamic braking of each motor in proportion to the inertia of its drive so that all motors will stop in approximately the same number of revolutions of the motors so that there will be no tendency for the arm to swing forward and cause the wire to break. To meet this condition, the most severe braking is on the last stand motor which has more effective inertia due to the smaller gear ratio, and also due to the fact that it is carrying a bundle of wire.

To be certain that the motors will commutate well under this extremely severe braking condition, the motors have especially designed interpoles and main poles which has the effect of more fully compensating the motor for the armature reaction and thus reducing the commutating voltages.

These motors are usually supplied with forced ventilation, the same air being used to cool the motors as is used for cooling the blocks themselves. Therefore, the motors usually run at a very satisfactory temperature even when carrying heavy loads so that again the important item of motor design is the matter of commutation.

The above comments refer entirely to the electrical characteristics of the machine. This motor is also of a special mechanical construction due to the fact that it mounts directly upon the machine by means of a flange fit at the bracket on the coupling end of the motor. On some of these machines, the worm is actually cut directly on the motor shaft, but in later designs, this construction has been changed and the motor now is connected to the machine gearing by means of a flexible coupling. However, the flange mounting is still used and the adapter that mounts the motor is also used as a duct for pulling air through the motor for cooling.

On single stand wire drawing machines, similar motor characteristics are required, although the problem of synchronizing several motors is not involved. However, the motors must be satisfactory for rapid deceleration and must also be designed to give high starting torques. In addition to the ordinary stabilizing series field normally supplied, there is also supplied an additional series field which is connected in the circuit during the starting period only and due to the fact that this winding carries the accelerating current, a greater starting torque is obtained for a given accelerating current.

The control consists simply of a main line and dynamic braking contactor for each individual motor and with a common accelerating resistor and accelerating contactors for all of the motors. This common accelerating resistor has an advantage in that it keeps the same voltage across motor armatures during the accelerating period and tends to keep them running at the same

speed independent of the load on the individual motor.

The accelerating resistor must be adjusted to exert torques slightly in excess of the maximum torque required when all five motors have been threaded and are ready to accelerate. If this torque is not high enough, there is a tendency for the motors to stall while the threading lever is held depressed and, on the other hand, if this starting torque is too high, the finishing block motor tends to start too fast when pulling the point of the wire through the die, which has a tendency to jerk the tongs off of the end of the wire or else break off the point.

A sufficient number of accelerating points must be supplied to give a rather smooth and slow acceleration in order to avoid breaking the wire since when the accelerating contactor closes there is a momentary change of torque, and also to make the changes in speed when accelerating contactor closes sufficiently soft so that the dancers are able to make any speed corrections required without causing them to pull over against the stop and break the wire.

Probably the hardest working and the most essential single control item is the dancer rheostat which controls the speed of the motor. This rheostat must be constructed especially strong mechanically in order to stand up under the continual regulating condition and also due to the shock load obtained when a wire breaks which almost instantly returns the rheostat back to its "off" position.

When wire breaks, the heavy spring on the dancer rheostat very rapidly returns the dancer arm back to its "off" position. As it reaches the "off" position, it strikes a stop which means that the arm and the rheostat mechanism must decelerate to zero speed very quickly. Although the inertia of the rheostat arm is very slight, the very rapid stop sets up very heavy stresses in the rheostat arm and shaft and is likely to cause a failure in the various parts of the assembly unless they are all made sufficiently strong.

On some wire drawing machines, especially those used for drawing spring steel, the motor speed range is apt to be between three and four to one and under these conditions the dancer rheostat only contains a portion of the ohms required for the total speed range and the rest of the resistance is contained in a special rheostat, that is designed to change not only the speed of the last block motor but also to change the speed of the rest of the motors a similar amount. This rheostat is also designed so that there is a rheostat plate in each motor circuit and each plate can be individually adjusted in order to make any relative correction in the amount of resistance so that all of the rheostat dancer arms will operate in the same relative position on the machine.

Although circumstances may alter the condition, it is usual practice to place approximately 50 per cent on the speed range control in the dancer rheostat and the additional 50 per cent speed range control in the remote mounted hand operated rheostat.

A. I. & S. E.

OCTOBER MEETINGS

PITTSBURGH DISTRICT SECTION

"Electrical Equipment for the New Edgar Thomson Slabbing Mill"

By

R. H. Wright, Steel Mill Engineer,

and

B. J. Auburn, Control Specialist,

Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

October 24th
Dinner 6:30 P .M.
Meeting 8:00 P. M.

Cardinal Room,
Wm Penn Hotel
Pittsburgh, Pa.

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DETROIT DISTRICT SECTION

"Electricity—Coal to Customer"

By S. M. Dean, Detroit Edison Company, Detroit, Michigan.

October 17th
Dinner 6:30 P. M.
Meeting 8:00 P. M.

Silver Room, Detroit Leland Hotel
Detroit Edison Auditorium
Detroit, Michigan

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

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BRENT WILEY, Editor.

Sworn to and subscribed before me this first day of October, 1939.

G. WILLIAM JONES, JR. Notary Public.

(My commission expires February 9, 1943.)

Engineering MOTOR

By C. P. SULLIVAN

Construction Engineering Department

GENERAL ELECTRIC COMPANY

Schenectady, New York

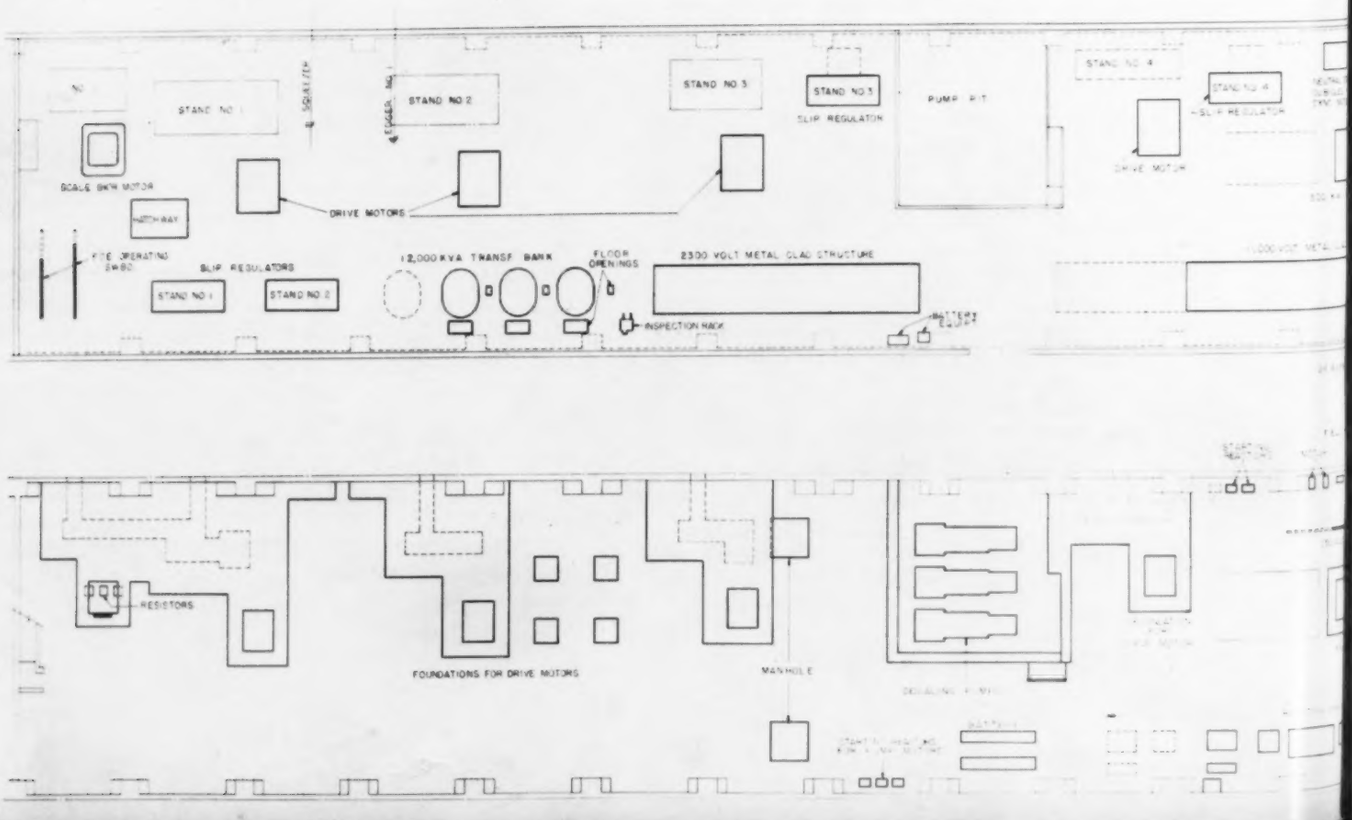
Presented before the A. I. S. E.
Philadelphia Section, February 4, 1939

▲ WHEN a steel company is planning to build a new mill, one of the problems that must be considered is that of motor room design. Wherever possible electrical rotating equipment, together with its switchgear and control, should be housed in clean, well ventilated, well illuminated rooms. Protecting the electrical equipment in this manner from dirt and also from possible excessive temperatures adds to the life of the equipment, as well as reduces the cost of maintenance.

The development of a motor room design can best be illustrated by taking some type of motor room design as a model. A continuous hot strip mill motor room is chosen as such a model as it brings out the problems of motor room design to a somewhat greater degree than other types of mill motor rooms. It must be remembered, however, that the design of motor rooms for smaller types of mills is just as vital to the mill it drives as is the design of larger motor rooms. A well designed motor room is just as important to a small cold reversing strip mill as it is to a large continuous hot strip mill. The premiums obtained from a well designed clean, well ventilated, well illuminated motor room are proportionally just as great in both cases.

The first rule for a successful electrical design of a motor room is for the designer to be on the job early. The electrical engineer must be in the picture from the beginning. Some of you no doubt have experienced the exasperated feeling, and this expression may be somewhat mild, of finding the space assigned to the motor room entirely inadequate for the equipment it was to house. The most skillful designer cannot entirely overcome this handicap of inadequate space.

The electrical manufacturer can be an important ally to the steel mill engineers at this beginning as well as during the following steps to the culmination in a well designed motor room. The manufacturer knows of course the physical dimensions of the equipment he



Layout drawing of modern hot strip mill motor room, showing general arrangement of all equipment.

Design of ROOMS

would offer for the new project, he has the experience derived from making previous similar layouts and is therefore well equipped to prepare a preliminary layout drawing of the new motor room if requested to do so.

Upon starting such a layout drawing, we find that the mill motors are already located by the mill designer. Since the motor locations are fixed, the motor room is built around the motors. The preliminary arrangement drawing serves its purpose in determining the overall dimensions and the elevations of the room, particularly the elevations of the main and basement floors. After due consideration by all concerned this drawing, in effect, is an approved drawing insofar as overall dimensions and elevations are concerned. The drawing may at this time be still preliminary as to the location of the equipment inside its wall excepting, of course, the mill motors. There have been some cases where the motors have been shifted somewhat after the preliminary electrical layout drawing has been completed but this is not generally the case.

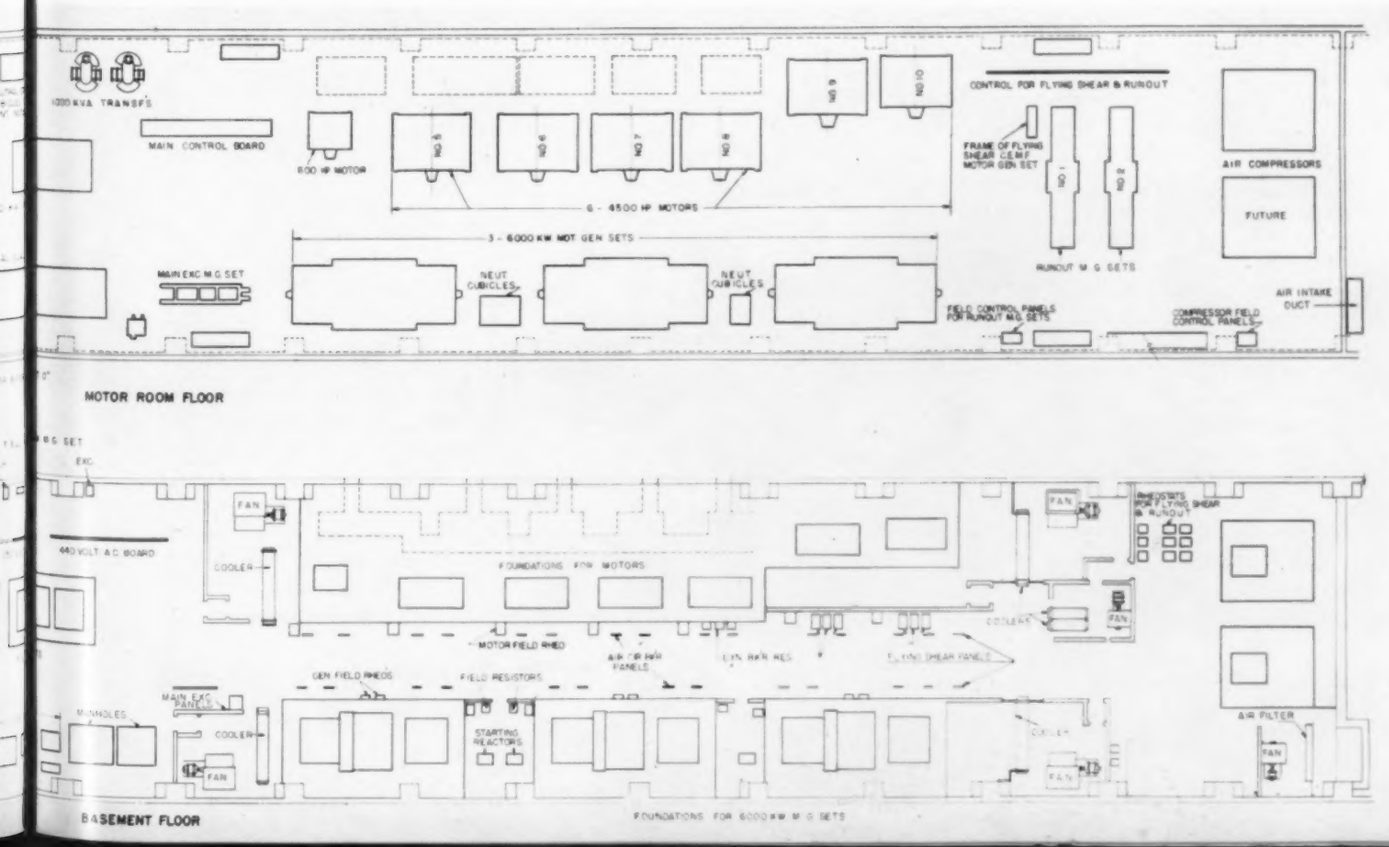
Although the preliminary layout drawing may not show final location of considerable of the equipment, in general the relative location of the equipment is shown on the drawing correctly. After the electrical equipment is purchased it can be given final locations after the outline drawings are received. The preliminary layout drawing then develops into the general arrangement drawing which is both the "Great Charter" and the chart of its motor room design.

In developing the general arrangement drawing the designer not only makes sure he has allowed enough space inside of the motor room walls for the electrical apparatus and for properly servicing same but that he has also included enough space and indicated the proper doors, hatches, etc., for installing the equipment and for removing same for major repairs. Space must be allotted for bringing the power and control circuits to and from the apparatus, both for circuits inside the motor room and for those that are brought to points outside the motor room, as for example, incoming lines, mill pulpits, etc.

It should be realized that the various points discussed hereafter in more or less separate sections are very much related in design. We often cannot make a decision concerning one aspect of the design without considering several.

One of the first decisions made is that of motor room elevations. The elevation of the mill is ordinarily determined before the motor room elevations. It is desirable to have the mill floor and the main motor room floor more or less at the same elevation, although this is not imperative. The elevation of the motors has been already determined. This information together with the elevation of the main floor of the motor room, determines the elevations of the tops of the bases of the various motors.

Sometimes the main floor elevation has been changed



View of motor room showing units located lower than floor level, a practice not generally recommended.

slightly to prevent the tops of the motor bases being small distances below the top of the floor. Having the top of a motor base a small distance from the surface of the floor is objectionable as articles may fall into the motor pit and this condition may even be a source of danger to anyone working around the motor. The top of motor generator set bases are often located some six inches above the floor for the above mentioned reasons. One safety feature used is to build vertical toe plates on the machine bases to prevent a person's foot or feet slipping off the base into the machine.

The elevation of the basement floor is, of course, being considered at the same time. One of the most striking features in modern motor room design is the more extensive use of motor room basements for the installation of electrical equipment. It would seem that from our domestic association of home basements as being coal bins, heating plants, and general storage areas, we did consider motor room basements as being of the same category. For some period, however, the motor room basement is being utilized for locating a great deal of equipment and becomes with proper illumination much more of a show place than the basements of older motor rooms.

The basement, because of the equipment it houses, may save main floor space and thus prove economical. The modern motor room basement is also essential for a good ventilation system as will be seen later. There is met by the designer on installations a reluctance of some persons associated with the job to provide a proper size of basement because of the so-called saving on excavation. This saving is sometimes theoretical as the excavation required for machine foundations and walls means that a small additional sum will provide for a complete basement.

Unfortunately, the presence of ground water or the danger of floods, limits the depth of the motor room basement in many cases. In one such case, for example, it was found necessary to screen off the section of the basement where d-c. connections are installed at the finishing mill motors and motor generator sets. Low headroom in this case under the buses crossing the basement is caused by the small space between the basement floor and the under side of the main floor beams.

It has been found that a distance of approximately 15 feet from basement floor to main floor provides sufficient basement height. Assuming the combined depth of main floor and floor beams to be 3 feet gives a distance of 12 feet from the under side of the floor beams to the basement floor.

We will assume that the mill under discussion consists of a conventional four stand roughing mill plus scale breaker driven by a-c. motors with a six stand finishing mill plus scale breaker driven by d-c. motors. The a-c. roughing mill motors receive power from 2300 volts, 6600 volts or some other suitable voltage through oil circuit breakers. The power to the d-c. finishing mill motors is supplied from two or three synchronous motor generator sets.

The designer finds that the end wall next to the furnaces which is naturally at the roughing mill end of the motor room and the wall between the motor room and mill are about fixed as to location. The motors can be located on the layout drawing to scale from mill designer locations and motor outlines and we find the motor gears are also inside the motor room. Templates of stiff paper or cardboard are then made for the remaining equipment to be installed in the motor room and with a supply of pins for holding the templates on the drawing board and high hopes the design is started. The other long wall of the motor room is somewhat dependent on the size of the furnace as the motor room does not extend into the slabyard. The remaining end wall must be past the last finishing stand motor and additional space beyond this point is often allotted in the motor room for flying shear control panels and runout table motor generator sets and panels.

It may be asked why all the admonitions to be on the job early if the dimensions of the motor room are naturally so limited by other considerations than the electrical equipment it must house. The electrical engineer may find the extreme limits of his motor room fixed but he often finds he cannot go to these extreme limits unless he has a good story to tell and especially a good general layout drawing to back up his story.

The motor-generator sets are usually located on the side of the motor room opposite to the d-c. motors. This results in an economical set-up for main d-c. connections between the generators and the motors. The relative location of d-c. motors and motor-generator sets, taking into consideration mounting of air circuit breaker panels in the basement, determines the final width of the motor room.

It is interesting to note that about 64 ft. from inside wall to inside wall has been used for the width of recent wide hot strip mill motor rooms. Cutting this space to

approximately 60 ft. in one installation resulted in a problem of d-c. connections which will be discussed later.

When the roughing mill induction motor secondaries are controlled by liquid slip regulators, the latter are located on the main floor of the motor room not far from their respective motors. As these regulators are large and also higher than the motors they control the location should not be such as to hit one in the eye when taking a general view of the room. For the sake of appearance sometimes the operating mechanisms and counterweights of the slip regulators are turned toward the wall of the motor room. If magnetic control is furnished for the motor secondaries, the panels and resistors can be located on the main floor or in the basement, or the panel may be located on the main floor with the resistors in the basement below. Where secondary panels and resistors are located on the main floor the resistors should not be located on top of the panel framework or tie rods as this makes the resistors too conspicuous. There is one installation for such service incorporating a dead-front construction of the panel with the resistors in rear on a unit framework, this assembly making a very neat appearance.

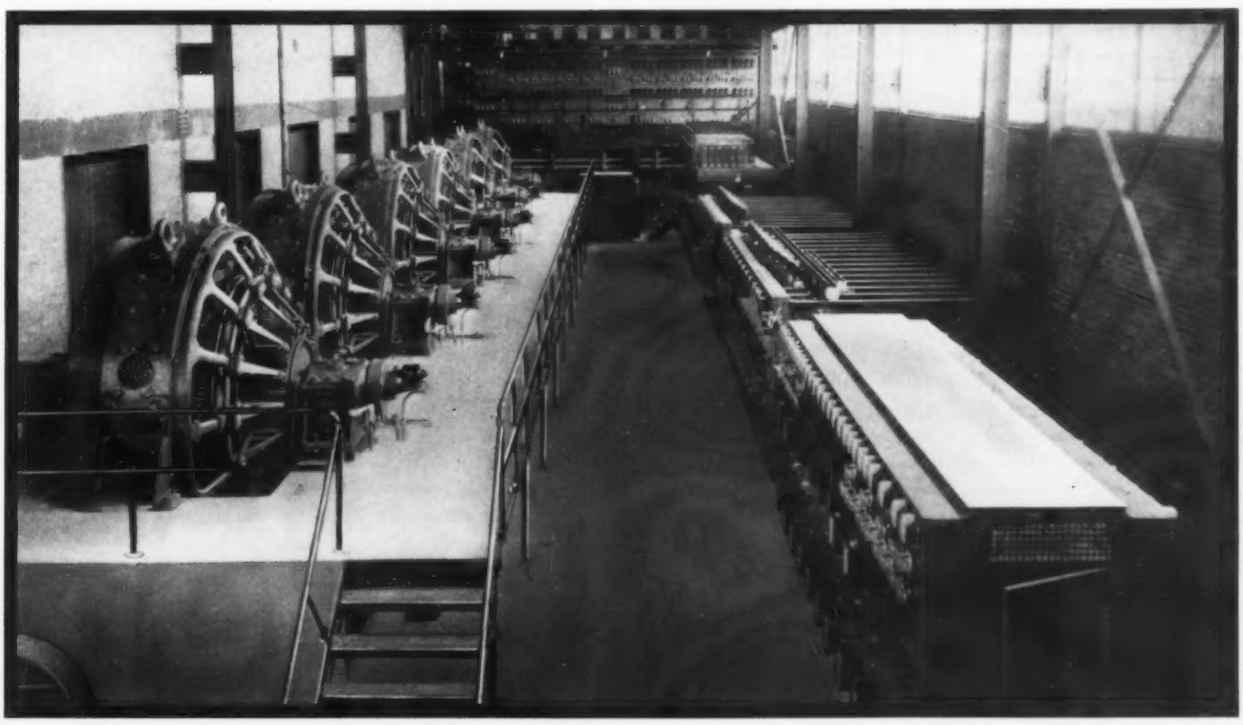
Main connections between roughing mill motor secondaries and slip regulators or secondary panels are often installed as single conductor cable instead of copper bar. Single conductor cables are used instead of three conductor cables to avoid a multiple of the latter because of the load requirements. Single conductor cable installed in transite duct is less expensive than copper bar on insulators and also safer.

Primary switchgear is, of course, one of the most important pieces of equipment in our motor room. The steel mill industry has adopted the metal-clad construction of switch-gear as its own. The many advantages of this type of switch-gear are well known but can bear repeating briefly. These points of appearance and compactness, ease and speed of installation, and safety features have made metal clad switchgear a part of the modern steel mill motor room.

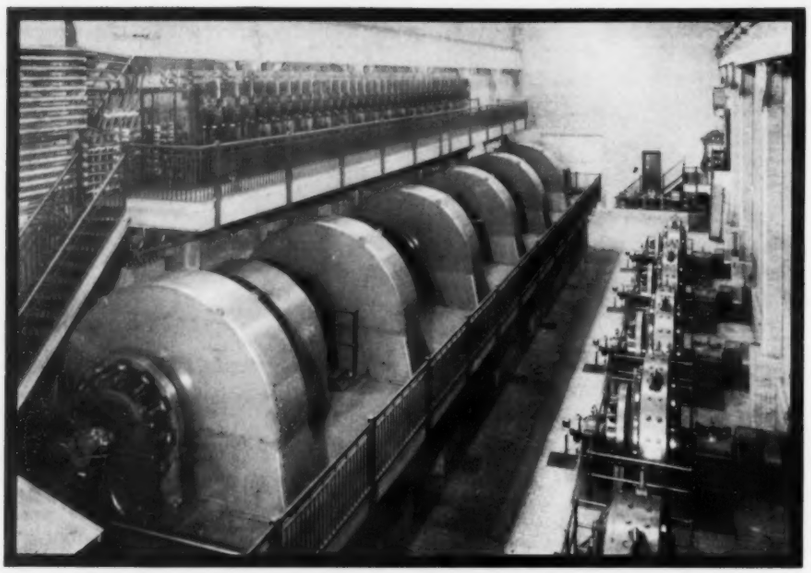
For the type of motor room we are considering, the switchgear is usually located between the a-c. motors and the d-c. motors. This location somewhat balances the length of cable runs from the oil circuit breakers to the a-c. roughing mill motors and from the oil circuit breakers to the synchronous motors of the main and auxiliary motor-generator sets.

Two advantages of metal-clad switchgear mentioned previously are its ease and speed of installation. To take advantage of this feature, the designer must provide a framework in the floor for mounting this switchgear. This framework provides a suitable means of leveling up and fastening the metal-clad units. This continuous framework is installed on top of the main floor beams, the top of this framework being at motor room elevation, with adjustable features being provided for leveling the metal-clad units.

Duplex control panels are now found in the modern steel mill motor room. Their steel construction of front and rear panels entirely enclosed make the duplex panels a fitting companion to metal clad switchgear. The space between the front and rear sections makes a splendid area for bringing control and instrument circuits to the panels. The duplex panels or duplex board as it is sometimes called is located in the area ahead of



General view of motor room showing mill drive motors located at a considerable height above motor room floor.



In this case, motor-generator sets are raised above mill drive elevation, and control panels placed above the motor-generator sets.

the finishing mill scale breaker. This is a convenient place for the motor room operator to establish his desk as it is fairly near the center of the room. Care should be taken not to place these panels in or too close to the aisle, that extends the length of the motor room.

As common to other mills of its type, 250 volt d-c. power is required for the auxiliaries. The motor-generator set or sets with the generator and d-c. feeder air circuit breakers are usually installed in the motor room. The space in the motor room between the last roughing stand motor and the d-c. scale breaker motor is often used for this equipment. This space results from the mill designer providing space in the mill for cooling the metal before it enters the finishing stands. The air circuit breaker panels for generator and feeders have been located on the main floor, in the basement, and on galleries with equally good results.

Auxiliary a-c. power is supplied by a 3-phase transformer or transformer bank of single phase units. Such transformers have been located outdoors or outside the motor room in the mill proper. They have also been located inside the motor room in vaults. The modern transformer with non-inflammable liquid in place of insulating oil allows the transformer to be placed in the motor room without any vaults or other protection. When transformers are located outside the motor room, they are usually close to the motor room wall so that the secondary connections can be brought overhead from the transformer into the motor room. The 440 volt or 220 volt distribution feeder panels are then located near the wall where the secondary leads enter from the transformer.

With a non-inflammable cooling and insulating medium these transformers and the feeder panels can be located nearer the center of distribution and at more convenient locations than for oil filled transformers. The oil filled transformers can be, of course, placed in vaults in the motor room, but such a vault should be ventilated and more space is required than for the non-inflammable type of transformer.

Assuming that an agreement has been reached concerning the general arrangement drawing and the elevation of the motor room main floor, basement floor, and gallery floor (if any), work can now be started on the so-called working drawings. The first step in actual construction work of a motor room is excavation, followed by the building of foundations of the motor room proper and the electrical machinery. It is, of course, possible that little or no excavation is required, but this is the exception rather than the rule. Consequently, the first drawings required are foundation drawings of the building, basement walls, and electrical equipment. Generally speaking, a building design section is responsible for the drawings of the actual building—that is, drawings of the steel, concrete, brick, etc., making up the building proper.

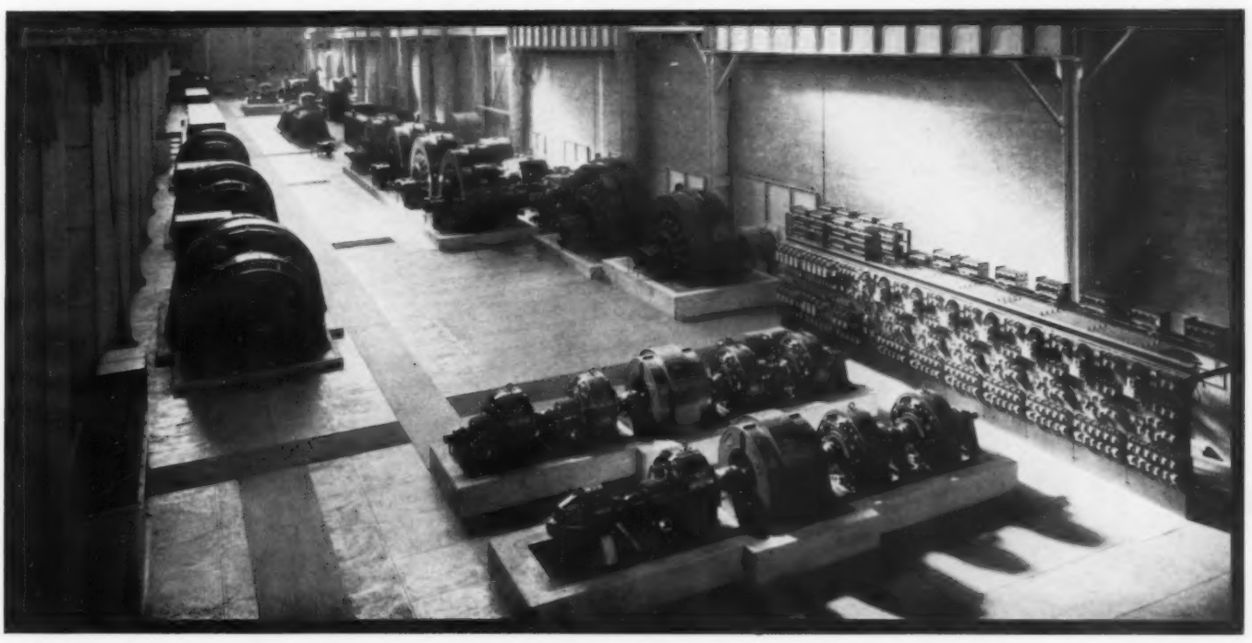
This same group of building designers is also responsible for the detail foundation drawing of the electrical equipment. The foundation designer, however, must have a drawing or information from the electrical designer giving the size of openings required for electrical connections and for ventilation. A drawing made for this purpose will show the outline and the overall dimensions of the foundations as well as the required openings for electrical connections and ventilation. The inside walls of the foundation are $1\frac{1}{2}$ in. to 2 in. inside the machine base. The thickness of the foundation walls is from 2 ft. 6 in. to 3 ft. for the size of machines we are considering, assuming approximately 15 ft. from basement floor to main floor. The machine foundations are generally of reinforced concrete, but there are some cases of steel framework foundations for rotating electrical equipment. For the cables, an opening can be left for the conduit, or fibre sleeves can be placed in the foundation, through which conduit will later run. It is not always satisfactory to install lengths of conduit in foundations to which conduit will later be joined as these lengths of conduit in the foundation are difficult to hold in a line during the pouring of the foundations and are liable to be damaged before the remaining conduit is joined to them. For bus connections, an opening is left in the foundation wall for the installation of an insulating slab which will support and insulate the bus. The size of ventilation openings

for the machine is determined by the quantity of air required and the location of the machine with respect to the ventilation system.

One of the major problems confronting the electrical designer of steel mill motor rooms has come into being with the growth in capacity of the hot strip mills themselves. The compact arrangement of finishing mill drives as well as the increase in size of d-c. motors has added to this problem. The d-c. bus and d-c. motor and generator connections of the finishing mill stands must be designed for the maximum short-circuit current that may occur. The conventional panel arrangement for hot strip mill motor rooms formerly was to group all circuit breakers and disconnect switches for d-c. motors and generators together in one assembly, and this system is followed today for some mills with the smaller ratings of motors and where space is limited. The more recent large hot strip mill motor room installations are different in that the air circuit breakers for the d-c. motors and generators are located in front of their respective machine foundations in the motor room basement on both sides of the aisle between d-c. motors and motor-generator set foundations. The d-c. main bus is located in rear of and above the air circuit breakers, as close to the machine foundation as possible. The bus of one polarity is therefore close to the motor-generator foundation, while the bus of the opposite polarity is close to the d-c. motor foundation. The advantage of this arrangement is apparent when one considers that the forces due to short circuit are directly proportional to the distance between the positive and negative buses being considered. The force due to short circuit varies as the square of the current which is the reason increased size of d-c. motors and consequently d-c. generators for more recent mills has brought this problem to the fore. The larger strip mills, having a distance of 11 to 12 ft. between positive and negative bus, have much lower stresses due to short circuit when compared to the buses in rear of air circuit breaker panels assembled together. It should be realized, however, that it is not always possible to obtain such a wide spacing of buses as mentioned above. Sometimes the space between the motor-generator and motor foundations is not as great as that desired. The solution for this problem was met in one case by placing the air circuit breaker panels at right angles to the motor-generator and motor foundations rather than parallel with the foundations, which is the more conventional method. In this case the bus, or rather the positive and negative buses, were reinforced to meet the decreased distance between buses, which in this case was approixmately 7 ft. However, the depth of the basement was increased beyond the original depth first thought of to accommodate the d-c. bus and connections. This indicates that a compromise can be met by trading a somewhat narrower room for a deeper basement. It can be seen that the design of the bus affects the width of the motor room and also the height of the basement. The latter dimensions are affected by the cross-over connections, which must be high enough to give clearance for passageway. Where such a bus system is installed, this dimension of the cross-over connections, together with the design of the floor and floor beams for the main floor, gives the required distance between the basement floor and the main floor of the motor room.

The length of the main bus in the above example is greater than that for an assembly of all air circuit breakers together, but the motor and generator connections are comparatively short.

The type of conductor for the main d-c. bus and motor and generator connections is next determined. Copper bar has been used for such service and is still used. The capacity of drive has so increased that the



This motor room shows the usual practice of placing all equipment at about the same elevation, slightly above floor level.

standard rectangular copper bar of 4 x ¼, 6 x ¼, etc., requires complicated arrangement to provide enough capacity. In addition, the usual method of vertical mounting of the long axis of such copper bar, which gives better ampere rating due to better ventilation, does not give the best resistance against bending due to short circuit stresses. It is possible to stiffen such bar arrangement for stresses at right angles to the long axis of the bar by inserting spacers between the bars or, of course, by adding more bus supports. Buses of structural shape, either of copper or aluminum, have been used for this service in large hot strip mill installations. Such buses have also been used to some extent for a-c. and d-c. panel assemblies made in switchgear factories. The structural shapes are usually of channel, furnished in pairs, and for d-c. the two channels are back to back. For a-c. service the channels are placed opposite to those for d-c. service, that is, the flanges of the two channels are adjacent to each other forming an approximate square. This assembly reduces the skin effect of a-c. current. Aluminum channels for this service are true channel sections, being rolled on the same rolls as the structural aluminum shapes, the aluminum conductors being, of course, of a different alloy. Copper shapes are usually bent over plates and there is one type which is an extruded section of rectangular shape.

When structural shapes are used for connections they are furnished cut to length with the ends drilled for splicing. Copper bar is ordinarily furnished either in standard length of say 20 ft. or in random lengths of 15 to 25 ft. Even with a structural shape bus and connections considerable copper bar is required to make connections to air circuit breaker studs, machine terminals, for splicing, etc.

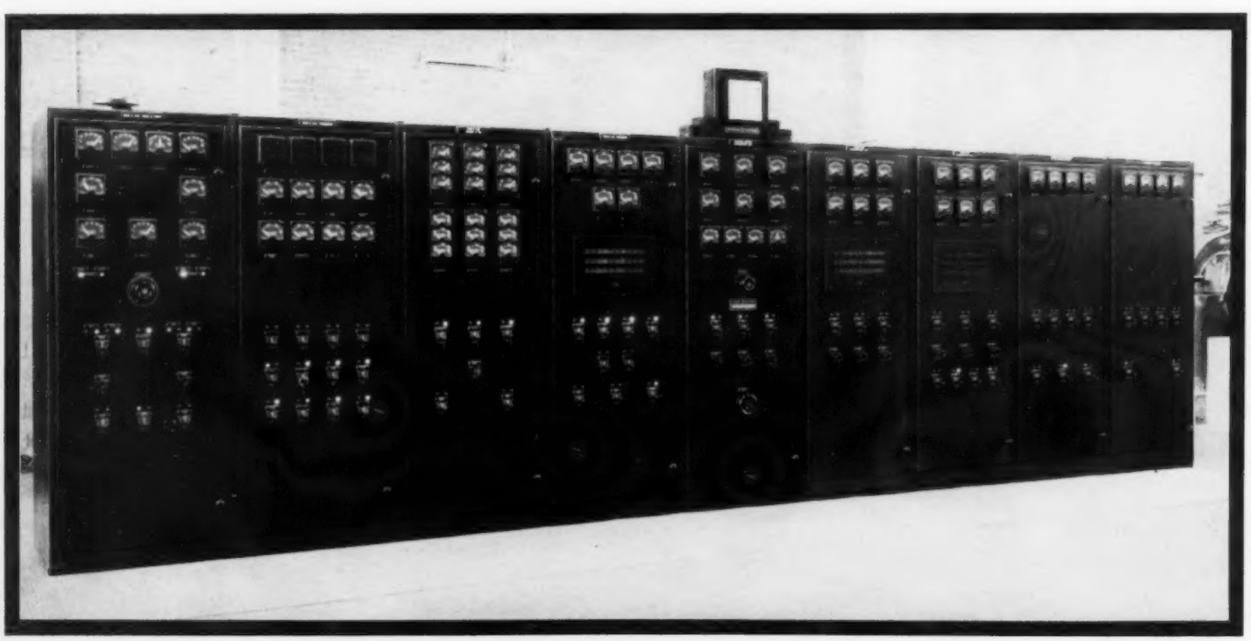
Care must be taken to provide expansion joints in the bus and connections where required. Stress due to the forces of expansion are just as destructive if not more so to porcelain insulators as are the forces due to short circuit current.

When a choice is made that a structural shape is to be used as the electrical conductor, the size of this conductor is determined from the rating of such conductors.

For aluminum channel conductors the main bus has been made up of two 10 in., 10.1 pounds per foot channels per polarity. This bus has a continuous rating of 9,000 amperes. Upon viewing either the drawings or actual installation of such a mill you will find the d-c. motor and generator connections are so sandwiched in on the main bus that no section of the main bus carries the current of more than one generator or motor.

The next question is that of insulating supports for the conductors. The insulated rod supports consisting of steel pipe with sleeve insulation and clamp fittings has been used for copper bar support for 600 volts and below. Porcelain insulators with suitable fittings for clamping or bolting the copper bars have also been used. The larger steel mill motor rooms have used porcelain insulators for supporting the structural shapes of copper conductors. The insulator chosen for such service depends on the expected short circuit stresses which it must withstand. Calculations are made of the expected forces, both in direction and magnitude, for the various combinations and arrangements of the bus and connections. This involves considerable work and extensive calculations as each point in the assembly of bus and connections is acted upon by every other member during short circuit, although many of the other members of the bus and connections have little effect on the particular location being studied. The results of the study are used in determining, not only the type of insulator, but also the location and spacing of same. One as-

Switchgear in the latest installations is largely of the factory-assembled metal-clad type.



sembly that has been used is that of a horizontal insulator attached to the bus for strengthening the vertical insulators in the assembly.

One ingenious method of bracing bus and connections against short circuit stresses is the use of wood strain insulators. The wood insulators are the common type used on overhead trolley system and are both inexpensive and easy to install.

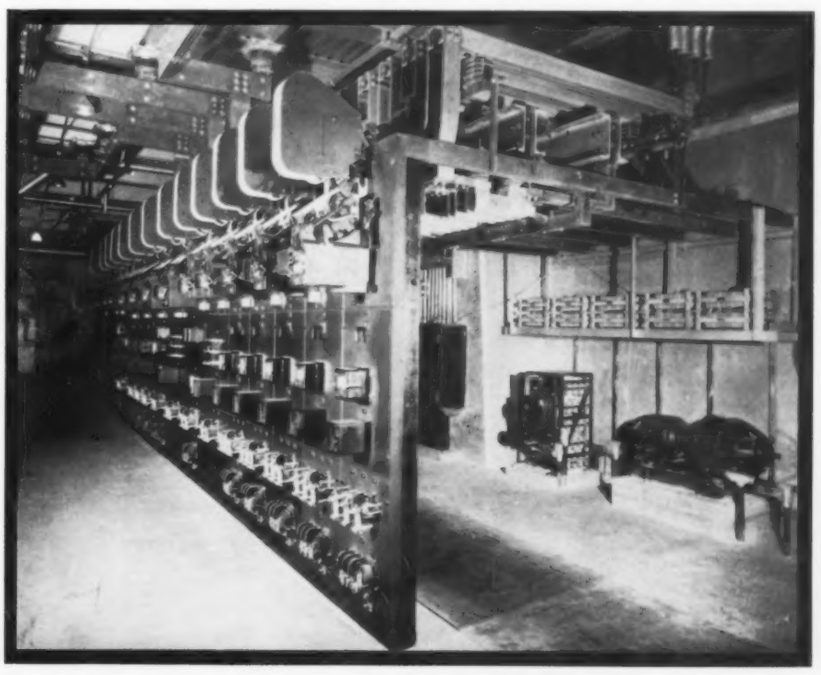
After electrical layout drawings are made of the bus and connection layout, the steel drawings for supporting the bus insulators are next in order. In fact, the electrical drawing must be prepared with the help of at least a preliminary steel layout of such framework. It is all important that the steel design be of sufficient strength to withstand the expected short circuit currents as well as the bus supports.

The conduit plan, together with a list of conduit and conductors is another important phase of electrical design of steel mill motor rooms and control houses. No matter how near perfect our design and manufacture of electrical apparatus may be, the equipment must be properly connected to have it perform its proper function. The conduit plan can be compared to the nerves of the human body, carrying from the brain or control panel the signals that cause the various parts of the body or equipment to function properly. The work of preparing conduit plans and list of conduit and conductors must be done correctly. The list of conduit and conductors referred to is an important tool to the installation construction foreman and to the steel mill engineer, not only during construction but also in checking troubles or for additions or changes to existing control or equipment. The system of conduit numbering would seem to require little consideration, but it must be clear and complete. One effective system is that using unit numbers. The unit numbers are assigned arbitrarily and one method is to take the general arrangement drawing giving a number to each of the motors, slip regulators, etc. Each unit of the metal clad switchgear and each panel of every group of panels as well as rheostats, etc., are also given a number. Each conduit run is then designated by the unit numbers at which it terminates. For example, a d-c. motor may be unit No. 10 and its field rheostat unit No. 50. The connection between the motor field and rheostat would be 10-50. If more than one conduit is required between the same unit, letters as A, B, C, etc., should be added to the conduit numbers to differentiate between these circuits. The circuit numbers used will be those appearing on the wiring diagram furnished by the electrical manufacturer. If necessary, the wiring diagram should be revised to agree with the list of conduit and conductors as to circuit numbers.

This necessarily close relationship between wiring diagrams and conduit plans is another reason why the electrical manufacturer can provide a real service by furnishing the conduit plan and details as well as the wiring diagrams. The close cooperation possible in such case has allowed work to be started on conduit layouts before final wiring diagrams were completed.

The information that should appear on the list of conduit and conductors is circuit number, size and length of conduit, type of circuit—as, for example, main, field or control—destination of circuit, size, make-up and length of cable, and, if desired, type of conduit fittings. This sounds simple enough but requires considerable work in the drafting room, as you can realize for some hot strip mills require as many as 1300 circuits for the motor room proper.

The path of the conduit must be decided upon. Conduits are often installed in the main floor of the motor room. The concrete must be of sufficient depth to encase the conduit and still have enough space for re-enforcing rods. Some motor rooms are designed with some conduit in main floor and other conduit in the open in the basement under the main floor. Conduits



Installation of switchgear for controlling auxiliary 250 volt d-c. system in modern strip mill.

have been installed in some cases in the main floor for the main leads to the synchronous motors of motor-generator sets and mill motors, but this practice is not always followed as it increases the depth of the motor room floor because of the large size of conduit required for these heavy a-c. circuits. With so much equipment now being installed in the larger motor room basements, conduit is also installed in the basement floor of such motor room. This practice necessitates in some cases installation of conduit in the foundation pads of the d-c. motors, motor-generator sets, and other machines, and this means that these conduit drawings are the first prepared for the installation.

The designer must be careful in the layout to make use of sufficient pull boxes for such circuits that require same. A large number of elbows should be avoided for any one circuit to prevent hard pulls of cables.

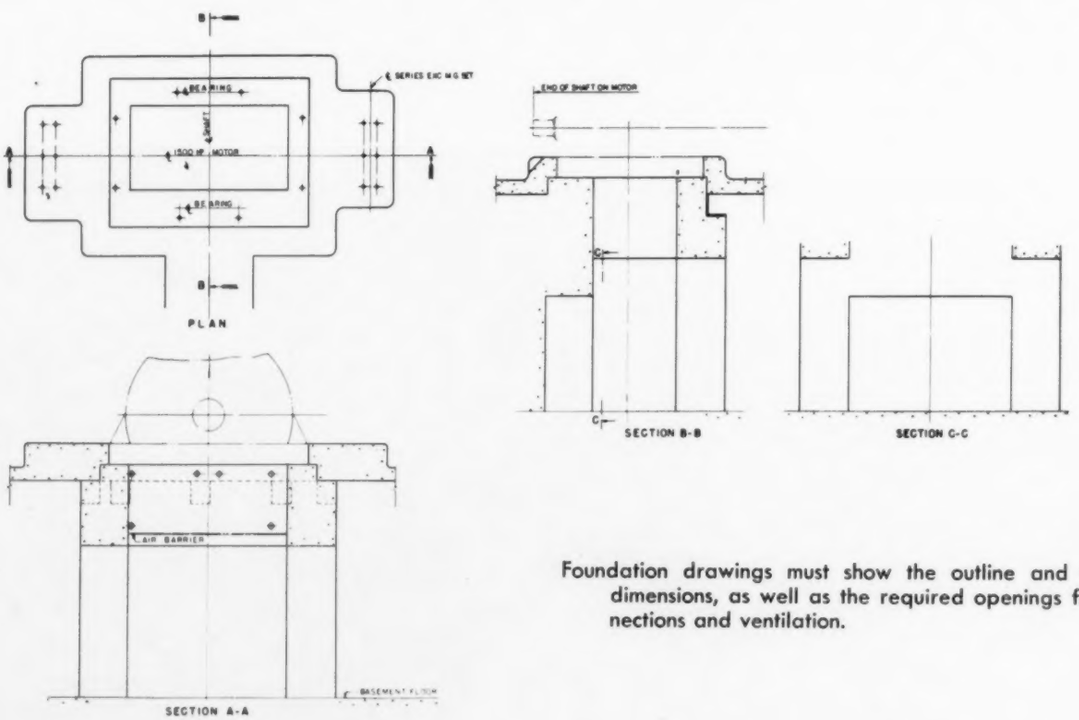
The list of conduits and conductors also includes data concerning type and make-up of cable.

This brings us to the subject of materials. The list of material giving quantities and description of installation material shown on the layout drawings is an essential part of the installation drawings. Each item of material is given a part number on the list and this same number appears on the installation drawings to help identify the material in the field. These numbers are also assigned arbitrarily but care must be taken in placing the proper item numbers on the installation drawings.

In general, varnished cambric insulation is more often used for the a-c. high voltage cables. Paper insulation is seldom used for this service as it must have lead sheath to protect it from moisture. Wiping lead sheaths is not a lost art but it is not always easy to find good wipers especially for work in vertical position.

Many steel mills over-insulate these high voltage cables to provide additional assurance against breakdown. Both lead and braided finishes are used for varnish cambric cable, with potheads being furnished for multi-conductor cable. For circuits 2300 volts and below the use of potheads for the cable is arbitrary but for circuits above 2300 volts potheads should be used. The cap nut type of pothead is used most generally for terminating such cables. Varnished cambric insulation is often used also for the lower a-c. voltages and the larger d-c. cables. Lead is used as a covering, especially for installation of such cable in basement floors or where there is danger of floods. Rubber insulation is usually used for control circuits. The advance in the art of manufacture of rubber insulation has led to the greater use of this more modern type of insulation. It is now possible to obtain rubber insulation not only for higher temperature ratings comparable to varnished cambric, but also insulation with moisture-resisting characteristics so that the lead sheath is not necessary, even in locations that formerly demanded a lead finish on cable.

We generally associate d-c. motor and generator main connections as being bus. The use of cable for these connections is more economical than bus up to about 2200 to 2600 amperes capacity which means about full load for a 2,000 hp. 600 volt d-c. motor as the upper limit. The limit varies depending on whether the comparison is for braided cable in open insulators or in conduit or if the cable is leaded.



Foundation drawings must show the outline and overall dimensions, as well as the required openings for connections and ventilation.

Single conductor a-c. cables must be installed in non-magnetic ducts. Installing single conductor cable in iron conduit would result in overheating the cable. As stated previously, placing such cable in fibre duct in the main floor is not recommended because the duct takes so much space in the floor and adds to the complication of conduit layout and installation. Such single conductor cable should be installed in the open under the main floor beams in transite duct. Transite duct is strong enough to be installed on racks similar to iron conduit.

Another important phase of the modern motor room is the ventilation layout. With the increase in size of motor room due to the increase in size and number of machines, the need of proper ventilation has grown stronger. Steel mill engineers have long recognized the necessity for clean air for the ventilation of machines and keeping machines clean is one chief reason for the building of motor rooms to enclose same. The conventional system used for a long period and still used to some degree today was to clean air either in an air washer or oil filter and, by means of a fan, blow the cleaned air into motor room basement, from where the air was forced through machines into the motor room proper. The air was taken from the motor room proper either through ventilators or openings to the outside of the room. This system served its purpose well, but even with high efficiency of air filters, dirt came into the room and required maintenance for cleaning of the machines. When one considers that a large motor room used as much as 480,000 cu. ft. per min. of air for ventilating the machines, it can be seen that a considerable amount of dirt will collect in a room, even in the course of a week. In addition to the amount of dirt that was carried into the motor room with this system, the fact that the hot air was released into the motor room increased the temperature of the room to uncomfortable heights.

The recirculating system of ventilation employing surface air coolers has been steadily growing in use in steel mill motor room applications. The first of such installations was in 1930. This system, as well as subsequent similar systems, serves the purpose of providing a clean motor room and, in addition, provides a cool motor room and definitely cooler machines, assuming proper design of the coolers, fans, ventilating ducts, etc., that make up the ventilating system. The surface air cooler which will be referred to in the following statement is made of a group of tubes wound with vertical fins, with water boxes at each end of the tubes for properly distributing the water through the tubes. The air passes over these fin tubes and the heat is transferred from the air through the fins and tubes into the water. The fins serve the purpose of exposing more surface for this transfer of heat, thus saving space and increased cost of such transfer equipment. The air is, of course, hotter than the water and the temperature of available cooling water must be lower than the cool air discharged from the surface air cooler.

The difference in temperature between the incoming water to the surface air coolers and the outgoing air from the coolers should not be less than 10 degrees F. Since air to machines must be no greater than 40 degrees C. or 104 degrees F. this means that the cooling water available must be no greater than 94 degrees F. In practically all cases the water temperature is 90 degrees F. or less. The surface air coolers provide a convenient method of regulating motor room temperatures by varying the quantity of cooling water excepting where water is at its peak temperature.

A general system for group cooling of machines is frequently used for d-c. motors and motor-generator sets. The heated air from the machines is drawn into the foundation pit of the machine by action of a fan. The foundations of the machines in any one group are connected together by an air duct and this heated air drawn to one or both ends of the foundation assembly. A surface air cooler consisting of one or more sections is placed at one or both ends of the group of foundations, together with a ventilating fan. The air is drawn or

View showing one method of arranging 600 volt d-c. switchgear and bus in motor room basement.

pushed through coolers by the fans, depending on the location of the fan with respect to the cooler. The non-overloadable type of ventilating fans is used. The cool air is either discharged into the motor room proper directly through ducts in the main floor or discharged into the basement, the air then finding its way into the motor room through openings in the floor, including stairways. The d-c. motors and generators for such a system of ventilation are usually supplied with back end-shields, the air being drawn into the machine across the commutator and down through back end-shields into the heated air duct in the machine foundation. Air barriers must be installed in the machine foundation to confine the heated air, and some means provided for adjusting size of heated air discharge openings at the bottom of the back end-shields. The cool air for the synchronous motors of the motor-generator sets is drawn through openings around the shaft at both sides of the motor and the heated air discharged through an opening in the bottom of the machine frame. This latter opening should also be adjustable to regulate the flow of air through the motor. The adjustment of the air opening discharging heated air from the machine is important for, if this is not done, one or more of the machines in the group will tend to take more than its share of the air from the system. This adjustment need not necessarily be very precise and one simple means of such adjustment is to install small sections of plates at the ends of the openings, and adjust air flow by adding or taking off these small plates.

The recirculating system of ventilation also includes make-up air, which is introduced into the room to make up for any air that might have escaped through the openings in the room. An air filter is provided, which

View of alternate method of arranging 600 volt d-c. switchgear, necessitated by available space.

LIST OF CONDUITS AND CONDUCTORS

Circuit Numbers	CONDUITS			DESCRIPTION			VOLTAGE OF CIRCUIT	CONDUCTORS				List 111-37K	INSULATION		QUANTITY				FITTINGS				COVERS	
	Conduits Intended for Future Use	Size of Conduit	*Total Length in Feet	Circuit	From	To		Total Tubes per Conduit	Total Conductors per Cable	Size of Conductors A. W. G. or C. M.	Total Length in Feet		Make-up	Volts	Elbows 45 deg.	Elbows 90 deg.	Bushings	Locknuts	Quantity	Cat. No.	Quantity	Cat. No.	Quantity	Cat. No.
					1500 KW. 250 V. GENERATORS #4																			
16-74				Power	Gen. #4	Gen. # 4 Pos. panel	250		Bar	Connections														
16-75A				Power	Gen. #4	Gen. #4 Neg. panel	250		Bar	Connections														
16-75B		1¼″	140	Contr.	Gen. #4 Comm. Fld.	Gen. #4 Neg. panel	250	1	Three	#12 AWG	150	C6	R.C.B.	600		5	2		1	E47	1	PTB1261	1	4773
16-75C		1¼″	140	Field	Gen. #4	Gen. #4 Neg. panel	250	1	Two	#6 AWG	150	C13	R.C.B.	600		5	2		1	E47	1	PTB1261	1	4772
75-177		1¼″	20	Field	Gen. #4 Neg. panel	Gen. #4 Rheo.	250	1	Two	#6 AWG	25	C13	R.C.B.	600		1	1		1	E47			1	4772
75-84		1¼″	40	Field	Gen. #4 Neg. panel	C.E.M.F. Gen.	250	1	Two	#6 AWG	45	C13	R.C.B.	600		2	2	1						
75-85		1¼″	40	Motor	Gen. #4 Neg. panel	C.E.M.F. Mot.		1	Two	#6 AWG	45	C13	R.C.B.	600		2	2	1						
								1	One	#12 AWG	45	C5	R.C.B.	600										
61-75A		2″	55	Contr.	Duplex Bd. #61	Gen. #4 Neg. panel		1	Ten	#12 AWG	60	C10	R.C.B.	600		2	2							
61-75B		1½″	55	Contr.	Duplex Bd. #61	Gen. #4 Neg. panel		1	Eight	#12 AWG	60	C9	R.C.B.	600		2	2							
61-74		2″	55	Contr.	Duplex Bd. #61	Gen. #4 Pos. panel		1	Ten	#12 AWG	60	C10	R.C.B.	600		2	2							
74-109		1″	180	Contr.	Gen. #4 Pos. panel	Gen. #1 Neg. panel		2	One	#12 AWG	375	C5	R.C.B.	600		6	2							
61-177		1¼″	60	Contr.	Duplex Bd. #61	Gen. #4 Rheo.		1	Four	#12 AWG	70	C7	R.C.B.	600		2	1		1	E47			1	4774
61-84		1″	30	Field	Duplex Bd. #61	C.E.M.F. Gen. field		1	Four	#12 AWG	40	C7	R.C.B.	600		1	2							
16-61		1″	80	Amm.	Gen. #4	Duplex Bd. #61	250	2	One	#12 AWG	175	C5	R.C.B.	600		5	1		1	E37	1	PTB1260	1	3772
61-176	61-176	1¼″	60	Contr.	Duplex Bd. #61	Fut. Gen. #5 Rheo.										2	2	(Capped)						

*INCLUDING 10% EXTRA

is connected to the outside air. The air is drawn through the filter by a small fan, which in turn discharges the air into the ventilating system. It must be understood that a successful recirculating system must have a tight motor room and basement to prevent excessive loss of air as the make-up air being provided is a small percentage of the total cu. ft. per min. required for the ventilation system. This percentage of make-up air is usually 10 per cent or less of the total cu. ft. per min. required by the machine.

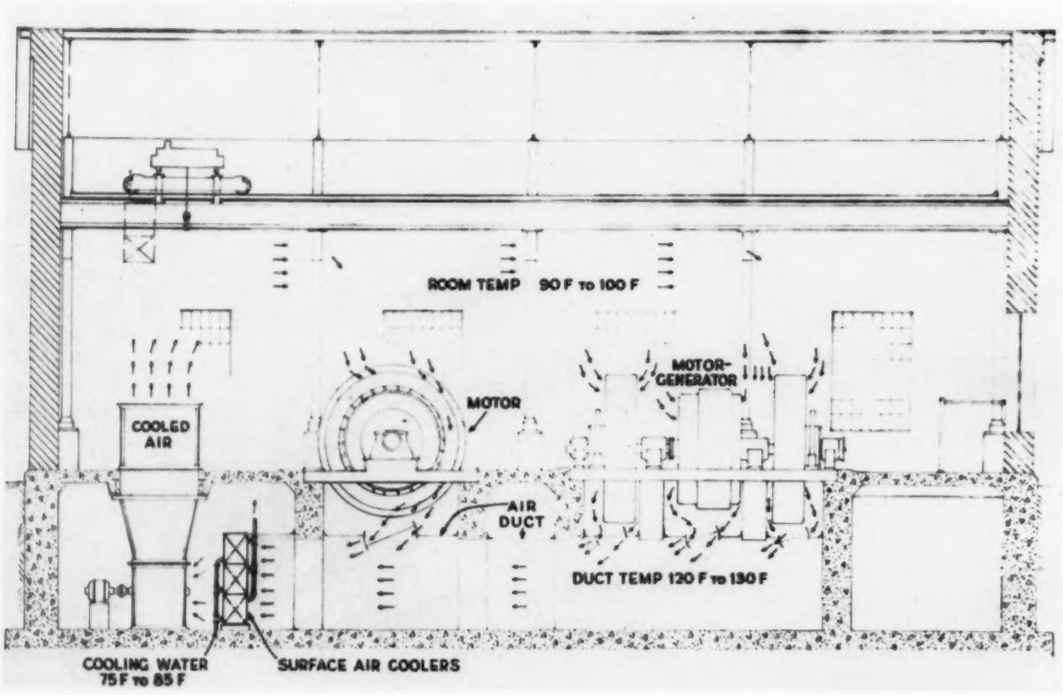
The ventilation of a group of machines has been discussed. It is possible to ventilate the roughing mill a-c. motors and also the synchronous motors of motor-generator sets as separate enclosed systems within the main recirculating system. In such case, the surface air cooler, fan and ducts form a closed system which, assumed to be theoretically tight, has no interchange of air with the air in the motor room. A-c. mill motors and synchronous motors can be designed to provide a slight excess pressure for forcing air through an external air system. In some installations no ventilating fan is required and only a surface air cooler is supplied, with the necessary ducts for bringing the air to the cooler and back into the machine from the cooler, With the proper height of basement, the surface air cooler, fan and ductwork can usually be installed inside the limits of the motor foundations being ventilated.

It must be realized that the elimination of the fan from the system is not all gain and, in fact, may be the reverse. The low external pressure drop available from the motor means a larger surface air cooler than where an external fan is used. The external fan in such case provides a higher external pressure than the motor itself for forcing the air through the cooler. This means that for unit of surface exposed to the flow of air, a greater transfer of air can be obtained through the surface of fins and tubes into the cooling water in the tubes; this in turn means less surface required for such transfer of a definite amount of heat, and consequently a less expensive cooler. Under certain conditions, the cooler and fan may be less expensive than the cooler alone for a system not using an external fan. In addition, the larger section or sections of coolers required for the system without external fan may not fit inside the motor foundation.

As stated before, and it bears repeating, the smaller motor room can utilize good design to the same advantage as can the larger motor room, and this system of closed recirculation will prove its worth for all types of motor rooms.

In reviewing the motor room design of similar mills one finds that they are perhaps similar but not duplicates. Each design presents different problems and in solving these problems the designer uses the experience gained from other motor room layouts. There is existing an expression to the effect that you can standardize engineering methods, but you can not standardize engineering thoughts. This expression applies to motor room design in that our methods may be somewhat standard, but our minds are still open to new thoughts and ideas to improve such designs.

Cross-sectional drawing of motor room showing typical down-draft recirculating ventilation system with surface air coolers.



DISCUSSION

PRESENTED BY

F. O. SCHNURE, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland.

N. C. BYE, Chief Engineer, Henry Disston and Sons Company, Philadelphia, Pennsylvania.

W. J. REA, Assistant Superintendent of Maintenance, Bethlehem Steel Company, Bethlehem, Pennsylvania.

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.

FRED SCHOEN, Assistant to Plant Engineer, Midvale Steel Company, Nicetown, Philadelphia, Pennsylvania.

C. P. SULLIVAN, Construction Engineering Department, General Electric Company, Schenectady, New York.

L. H. FISTER, Foreman, Power and Transmission, Bethlehem Steel Company, Bethlehem, Pennsylvania.

H. H. ANGEL, Control Specialist, Bethlehem Steel Company, Sparrows Point, Maryland.

L. A. UMANSKY, Steel Mill Engineer, Industrial Department, General Electric Company, Schenectady, New York.

F. O. SCHNURE: One of the factors in the construction of motor rooms is that of being able to lay the conduit in the minimum time, once the building steel is in place. The design of our recent motor rooms has called for corrugated metal as a permanent base for the motor room floor instead of the customary temporary wood forms. This material can be laid as fast as men can carry it and thus make the entire area available for the placing of conduits within a very short time. On our hot strip mill job this design permitted the installation of conduits in about one-fourth the usual time.

The floors are 15 to 18 in. thick and the original idea was to pour the first foot with sand, but being afraid of voids if the sand would trickle out where the fits were not perfect, the first 75 per cent of the floor was poured with a very lean mixture of concrete and concrete reinforcing bars were used.

The most important thing to cover in motor room design is the ventilation. At least half of one million cubic feet of air per minute is required to dissipate the heat, and some hot strip mills had to add additional ventilating equipment to that originally installed. Hot strip mills and cold strip mills require a good bit of water, and where this water is low enough in temperature (in our case deep well water at about 62 degrees), surface coolers are entirely feasible and provide means to cool re-circulated air.

In our hot strip mill on a very hot day last summer, the air entering the motor room from the make up fan was 90 degrees F., the air leaving one of the 6000 kw. motor-generator sets was 120 degrees F., and was cooled by the air cooler and returned to the motor room at 75 degrees F., all of this from water at around 62 degrees. That contrasts with temperatures of 95 to 110 degrees in some of the old motor rooms with air coming out of the machines at from 138 degrees to 160 degrees F.

Years of life will be added to insulation where temperatures in the motor room can be kept at lower levels. Recently the temperature in the hot strip motor room was 72 degrees on the floor, 90 to 96 degrees leaving the motor-generator sets and returned from the coolers to the motor room at 66 degrees, all during a period when strip was being rolled at about 150 tons per hour.

There is a tendency to place the motor-generator sets out in the mill in order to save cranes and save sub-station buildings. I am not quite so sure this is a good place. It is perhaps all right if a basement is provided for switch gear control and cooling apparatus but from a safety standpoint, regulations will be increasingly rigid and motor rooms provide means for this isolation of electrical equipment except to those authorized.

N. C. BYE: I have a question to ask Mr. Sullivan How do you determine the amount of ventilation required?

C. P. SULLIVAN: The general rule used is to allow between 110 and 130 cu. ft. per min. per kilowatt loss, considering a ventilation design similar to that discussed consisting of a fan as well as a surface cooler. The fan must be of proper size as to volume of air and must deliver this air at proper pressure to provide for drop in the cooler as well as in the machine and duct work, if any, in the system.

W. J. REA: I would like to ask Mr. Schnure at what temperature the air leaves the machines, and what is the temperature of the winding itself?

F. O. SCHNURE: Answering Mr. Rea, it is general practice to assume that the windings are at least 15 to 20 degrees beyond the temperature of the stator iron.

L. F. COFFIN: Being a mechanical man I feel highly honored at being permitted to talk on this subject and thus to trespass on the sacred precincts of the motor room. In connection with surface coolers, it is entirely possible that circulating water systems may be economically applied to them, even in small units. In the 56 in. hot strip mill at Sparrows Point, artesian well water at a temperature of about 62 degrees F. is used at a pressure of 35 pounds and passes through several coolers in parallel with a pressure drop of 2½ pounds and then on to other uses. It is absolutely essential in an installation of this kind that the pressure drop of all coolers, regardless of capacity, be the same, otherwise larger coolers and smaller coolers will not get their proportional amount of water. The temperature rise of the water going through the coolers varies from five to ten degrees, so that when you have water starting at 62 degrees F., if it doesn't exceed 72 degrees F., it is still perfectly usable water under almost the initial pressure. The importance of designing all mechanical equipment that is to be located in motor rooms

so as to be free from oil leakage cannot be stressed too much. Much remains to be done in this direction.

F. C. SCHOEN: Mr. Sullivan spoke of the level of illumination. I would like to know what the proper level of illumination is, or what is considered the proper level for a motor room?

C. P. SULLIVAN: First of all, I am not an illuminating engineer. I have had some contact, of course, in discussing motor room designs with the mill owners themselves and I believe that the recommended level of illumination is between 12 and 15 ft. candles for motor rooms. I do not know if you can find a recommended illumination level for a steel mill motor room published in any article or book, but judging from recommendations given by illuminating engineers for motor rooms housing similar types of equipment, I believe 12 ft. to 15 ft. candles is a good level of illumination. In the pictures that were shown there were two different rooms shown each to have an expected 12 candles in operation. This allows for a certain percentage of depreciation in the illumination.

F. C. SCHOEN: Looking at some of those illustrations, I wonder how much room and how much consideration is paid for the repairman to get back of the boards which he has to do? It quite often happens that we don't have any working room back of the switch boards.

C. P. SULLIVAN: I think that the pictures are somewhat deceptive. The metal-clad units look as if there were no space in the rear. Actually on the particular installation shown there is some 6 ft. from the back of the units to the nearest building line. As far as excess to boards are concerned, you and I talk the same language because I am always fighting that battle. The particular air circuit breaker panels shown in the basement for main d-c. motors are also shown in a deceptive manner. These breaker panels are out in front of the arches of the motor foundations and since there is 18 in. from the front wall of the motor foundations plus an additional 24 to 30 in. in the arch space there is a good working space around these panels.

L. H. FISTER: Generally speaking the question of design of motor rooms in my opinion may be subdivided to cover two distinct groups, the first group covering new installations. I am not going to say anything about that because Mr. Sullivan covered that very completely and in detail. The second group covers improvements to present equipment.

Now, the significant thing to remember about this second group, to my way of thinking, is that many of the improvements made by all the industrial concerns are made simply to improve the factor of safety both to personnel and equipment and the equipment is not completely worn out, nor is it utterly useless, but we do feel that it cannot be depended upon to continue to function with any degree of security, and while what we want to substitute in place of such equipment must be more substantial, yet it does not necessarily follow that it has to be the very latest which is also usually the most expensive. I am inclined to the belief that we will provoke more or less discussion in work of this nature and I sometimes feel that we don't always get the same degree of cooperation from the manufacturers that we would or do receive on new installations.

I think everyone has made quite a few improvements in the last few years; some have increased the rate of production in the mills; others improved the factor of safety to personnel and equipment. In one location we practically doubled the motor horsepower per unit of room enclosure. We provided artificial ventilation in the form of a motor-driven fan taking the best air available from the mill, cleaning it, and conducting it to the motor room and operating very satisfactorily in that manner for some four or five years.

In another location I can recall that we completely rebuilt a primary bus structure and circuit breakers were installed and all the other associated equipment, and we also completely rewired both the primary and secondary circuits and relocated them in such a manner as to be well above the high water mark, inasmuch as we have experienced some three floods in the last six years, causing considerable delay and damage to the equipment.

There is just a question or two that I would like to ask Mr. Sullivan, and that is whether he is familiar with the approximate short-circuit current of these d-c. buses that he was speaking about? Another question is what provision was made to furnish power from more than one source in this down-draft ventilating scheme in the case of loss of power? How long can you continue to operate if you have lost your fans?

C. P. SULLIVAN: Answering the first question, there is nothing too definite concerning the expected short circuit current. That may sound rather confusing, but you will find a difference of opinion among authorities. I am not an authority, but for the particular mill that we were reviewing the expected short circuit current was in the neighborhood of 250,000 amperes. That short was not considered a dead short where you might tie the positive and negative buses solidly together. It was a short where we took into consideration an expected arc drop in the breakers upon opening.

Now as to the second question—a provision for ventilation in case of failure. In this particular mill we were reviewing if your power fails, you might say that you are out of luck. Many of these machines are so designed that with covers off they can be operated for some period of time. The ventilation system of the d-c. motors can still operate if one fan should fail. If one fan of such a system should fail the remaining fan or fans will provide more unit volume of air. For example, with two fans, each rated 80,000 cu. ft. per min. when operating together against a resistance pressure of 4 inches, when one fan is shut down the remaining fan will deliver more than 80,000 cu. ft. per min. This increase in volume is due to the decrease in the system resistance pressure caused by the total volume of air being less than 160,000 cu. ft. per min.

H. H. ANGEL: In the old days we used to have exposed pipe structures for high voltage equipment which necessitated signs strung around and sometimes rails and platforms so that our own electricians and oilers or visitors would not get mixed up with the high voltage equipment. Of course the present day equip-

ment eliminates the necessity of that as everything is enclosed.

In Mr. Sullivan's pictures, the 440 volt and 250 volt switching equipment circuit breakers were shown open and I would like to ask Mr. Sullivan if there are any purchasers of this equipment who demand that the 440 volt and 250 volt breakers mounted on the main motor room floors be enclosed? I understand that the Ford Motor Company has ordered such equipment in the past and I am just wondering how far they have gone with enclosures. Personally for maintenance reasons I don't think much of going too far in enclosing low voltage breakers.

C. P. SULLIVAN: I may not be up to date as to all of the recent installations with respect to enclosing such equipment. There is one installation where they have gone so far as to install blank vertical panel sections on top of the panels proper. A horizontal screen was then placed between the wall in rear of the panels and the top of the new blank panel sections to prevent anything from falling on the bus. Of course, a great many mills, as you know, put screens with doors in them at each end of panels and provide the doors with locks so that only authorized persons can go in rear of the panels.

L. A. UMANSKY: I would like to comment on a few points which were just brought up in the course of the discussion. I do not feel that the possibility of failure of ventilating equipment is actually a serious menace. In the first place, the fans and their driving motors are elementary, simple and reliable pieces of machinery. In many cases several fans are installed so that if one is out of service the supply of ventilating air is reduced, but is not cut off entirely. The fans ordinarily operate from a-c. low voltage power which is also used for operating the exciter sets and some essential auxiliary drives. Therefore, if this power supply fails the mill will go down anyway—and much sooner than would be called for by lack of ventilation.

In the majority of cases the electrical machines, if rated on 40 degree C. open basis, can operate indefinitely without fans but with ventilating covers, if any, removed. If these covers are not removed and the machines continue carrying their load, then they will overheat, but of course not instantly. For example, a low speed motor with a temperature rise of 40 degrees C. at the time when the fan has failed, can carry its rated load for not less than, say, ½ hour before the temperature rise reaches 50 degrees C.; a higher speed motor or an motor-generator set will probably operate under the same conditions for 2 hours or more. If the initial temperature rise was less than 40 degrees C., or if the load is less than normal, then the permissible time of operation without the fan and with the covers on is correspondingly increased.

The next question dealt with was the short circuit current which might occur on the 600 volt d-c. bus—of such mill as was discussed by Mr. Sullivan. Theoretically, if we provide a solid bolted connection between the positive and the negative buses, and then "throw a short", the current might go as high as ¾ million amperes, or even higher. Actually, it is not conceivable that such value will be encountered. Even if a proverbial crow-bar is placed between the buses, the contact resistance alone is sufficient to cut short circuit current to a much lower value. No direct test data are available, since no one is willing to risk his expensive installation for the sake of such an experiment. (If I am mistaken and such generous man or organization is available, I will be only too glad to bring an oscillograph to measure the short circuit current.)

When a short circuit occurs—as they sometimes do—the resultant stresses might distort somewhat the buses or the connections at the machines. From the magnitude of these distortions the mechanical stresses and, as the next step, the short circuit currents can be crudely evaluated. Several cases of this nature which were analyzed have never shown a much higher current than, say, 250,000 amperes. Thus it is reasonable, and presumably safe, to design and brace the 600 volt buses for mills of this type for a short circuit current of about that magnitude, with a suitable safety margin added to it.

The question of enclosures for 250 volt d-c. and 440 volt a-c. switchgear was also brought up. As far as I am concerned, I would favor the open type 250 volt d-c. switchgear. Such switchgear is logically located near the motor-generator sets. The latter are usually housed; hence the switchgear can be also located in the same motor room or substation. Once this is done, an additional steel enclosure seems to be superfluous and therefore expensive. This is particularly so since the 250 volt feeders are usually of large capacity, say 4000 amperes and larger, and making these breakers of the draw-out, truck type represents an appreciable expense. From safety viewpoint the 250 volt switchgear is not any more dangerous than the conventional control panels for various mill auxiliary drives. Enclosures for the latter may be considered when they are located open in the mill building or on crane rather than in a separate control house or motor room.

The 440 volt a-c. switchgear is in a somewhat different category. The step-down transformers, particularly if provided with non-inflammable liquid, can be located in the mill building, at the load center, and not necessarily in a housed substation. Therefore, the adjacent 440 volt switchgear, if likewise located in the mill building, can be built of the metal enclosed draw-out type. The extra cost of such metal enclosure is much less than the cost of a control house. The 440 volt feeders are ordinarily of smaller capacity than the d-c. 250 volt circuits.

An interesting refinement can be added to a water cooler installation, comprising part of a ventilating system. More often than not the valves controlling the water flow are set for the most severe conditions (heavy mill load in summertime); this flow is several times too great for the balance of the year, or even for the summer if the load is light. A thermostat can be readily added, responsive to the temperature of outgoing water (or air) and automatically controlling the flow of water. I believe that such an arrangement will certainly pay good dividends on the small additional cost involved.

After making all above comments, I want to come to the main point of my discussion. It has been brought out quite clearly by Mr. Sullivan how important it is

(*Please turn to page 68*)

A Tentative STANDARD for FITS and FINISHES in Maintenance Shops

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BETHLEHEM, PENNA.

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▲ IT is hardly necessary today to argue the advantages of standardization of size for machine parts that are intended to be interchangeable. The mass production industries had to develop limiting dimensions on particular parts before the assembly line became possible. At first each group produced its own standard, but later through the technical societies most interested, national standards were produced by nearly all of the industrial nations. Now, there is a tentative international standard at present adopted by most of the metric system users. The standardization of surface finish is about in the state that standardization of fits was, twenty years ago. Each group has its own ideas but there is as yet no general agreement on either the quality of surface desired or the methods of measuring this quality. At this time, research workers and technical committees are at work on this problem and a great deal has been written and published in the technical magazines.

Since most of these studies have been predicated on their use in mass production, the need of such standards in steel plant maintenance is not so clear. However, it is sometimes painfully obvious that too tight a fit or too rough a surface is expensive and most of us at some time or another discover that parts made from drawings showing a 6 in. shaft in a 6 in. hole do not all fit in the best possible manner. It requires only a brief study to list a number of other annoying and expensive experiences with fits and finishes and these point at once to the need of a standard of fits and finishes for steel plant maintenance shops.

Here is a brief list:

A. The draftsman does not always know what fit and finish should be applied, he may give the wrong information, or more likely none at all.

B. Unless some sort of symbols are agreed upon, there is no method by which the draftsman can specify finish.

C. Unless the drawing carries the information on size and finish, it is necessary for the shop foreman to give extra instructions and extra supervision to get what he thinks is right and do this every time the part is made.

D. The shop man does not know just how all parts are used. If forced to decide for himself, he will protect himself by making the part closer to dimension and of a higher grade finish than is necessary. This is often useless waste of money.

E. Interchangeable parts are made more often than at first seems likely. Many more parts should be made interchangeable.

F. It is often necessary to hold spare parts with the bore left small or the outside diameter large because no one knows exactly what size the mating part is. This makes a longer shutdown or sometimes requires that both parts be carried as spares. At the least it requires an extra set-up in the machine.

G. If mating parts are made in different sections of the shop without a set standard, there is much waste of time getting measurements from one part before completing the other.

H. Unless the proper correlation of sizes, from a standard or checking the mate, is accomplished extra time on the assembly floor or in the mill, and extra cost, is the result.

I. Unless the information concerning size and finish is complete, the machinist has a perfect alibi for a poor job.

This seems a terrible indictment of our shops. As a matter of fact, the large, important parts are well taken care of. The shop foreman and mill master mechanics make certain they represent the best experience. Between the mill men and the shop men, there has grown up a series of agreements on the often repeated jobs that make a sort of interchangeable manufacture of certain parts. There was a need, however, for a system that would have more general application to the thousands of small parts that represent a high percent of our

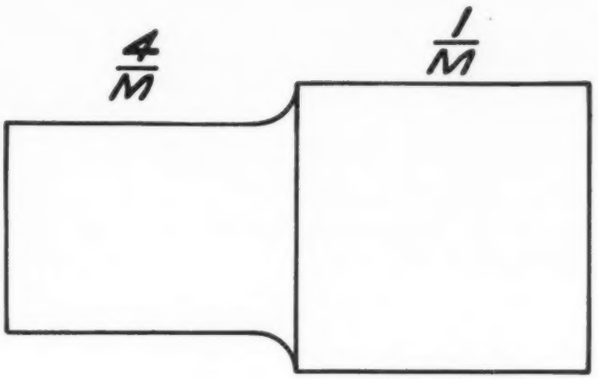


FIGURE 1—The desired type of finish is indicated on the drawing by marking as here shown.

maintenance cost. To eliminate as far as possible the above mentioned expensive annoyances, it was evident that it was necessary that the knowledge of the engineer, the mill master mechanic and the shop man should be employed to formulate some sort of standard of fits and finish. A committee representing the engineering department, the mill master mechanics and the machine shop foreman, have prepared the following tentative standards of fits and finishes.

FINISHES

The proposed standard for finishes is admittedly crude. Samples of the four machined finishes are to be furnished to the shops, apprentice school, master mechanics' office and engineering department. These are bars of stainless steel. The nomenclature is that suggested by F. O. Hoagland, master mechanic of Pratt and Whitney Company and a member of the American Standards Association.

Finish	Symbol
Rough machine	32/M
Commercial finish	4/M
Broad nose tool or roll	1/M
Fine finish grind	$2/\frac{}{X}$
As cast or forged	NF
Chip and file	16/M
Scrape to fit	S

The type of symbol is used with the hope that when the ASA standardizes finishes, they will be accepted. It has the particular advantages of actually meaning something. NF of course, is an abbreviation of no finish and S of scrape, but the others are a measure of the actual roughness of the pieces, M and X are roman numerals.

M—1000 $32/M = \frac{32}{M} = .032$ 1/32

$16/M = \frac{16}{M} = .016$ 1/64

$4/M = \frac{4}{M} = .004$

$1/M = \frac{1}{M} = .001$

$\frac{}{X} = 10000$ $\frac{2}{X} = .0002$

The roughness is measured by an ingenious gauge developed by Mr. Hoagland. (Figure 1). It is not intended to check each piece with a gauge but to use appearance and feel on the sample.

We occasionally see systems of fit and finishes in which the same symbol denoted the finish and size limits and probably this works satisfactorily for a particular piece. More often there is no direct relation between size and finish. A journal that is given a very loose fit should still be smoother than is necessary for some more accurate fits. Of course, when the size of a part is held to close limits, it is necessary to use grinding and a good finish.

Rough Machine —32/M

This type of finish can be accomplished on most any machine. When this finish is specified, the tolerance should be at least $\frac{1}{32}$ in. or plus or minus $\frac{1}{64}$ in.

Commercial Finish—4/M

This type of finish can be made on any machine. The tolerance can be made wide or close. It should not be specified any closer than about .002 in. plus or minus.

Broadnose Tool or Roll—1/M

A common finish accomplished with a square nose tool on either planer, vertical boring mill, horizontal boring mill or lathes. This finish is used where the surface is large and a fairly smooth and square surface is wanted. The tolerance can be held very close, plus or minus .001 in.

A rolled finish should be specified only where there is a journal or sliding surface as it is a polished finish, and costs more to make. Where practical and within the limits of our grinder, we will grind. The tolerance on this finish can be held within plus or minus .001 in.

Ground Finish—$2/\frac{}{X}$

This type of finish can be made very close, plus or minus .0002 in. The fineness of this finish can be governed by the grit of wheel used.

Our limits for grinding are limited by the equipment

which is a 24 in. x 240 in. cylindrical grinder and a 24 in. x 84 in. surface grinder.

EXAMPLES OF FINISH APPLICATIONS

Rough Machine

Standard car axles except journals and fit.
40 in. and 46 in. blooming mill crop shear blades—planed surface.
Outside diameter of tong stem spindles except bearing surfaces and gear fit.
Blooming mill spindles except journals and spades.
Re-turning car wheel treads.
Re-turning locomotive tires on outside diameter.

Commercial Finish

Blooming mill and plate mill table roller journal brasses.
Crane journal brasses.
All gear blanks except high speed gears.
Most all small parts that are finished on a turret lathe have this type of finish.
Small brass bushings.

Broad-nose Tool Finish or Rolled

Gas engine cylinder liners.
Blast furnace skip bucket bell rods.
All large mill lineshafting except journals.
Large press fits when not ground.
Outside diameter of large mill nuts.
Cylinder bores (mud guns, steam cylinders for ladle cars).
Gas engine crankshaft journals.
Gas engine piston rods.
Table roller journals, when not ground.
Large mill spindle journals.
40 in., 46 in. and 40 in. x 80 in. mill screw threads (polished).
Mill lineshafting journals, when not ground.

Ground Finish

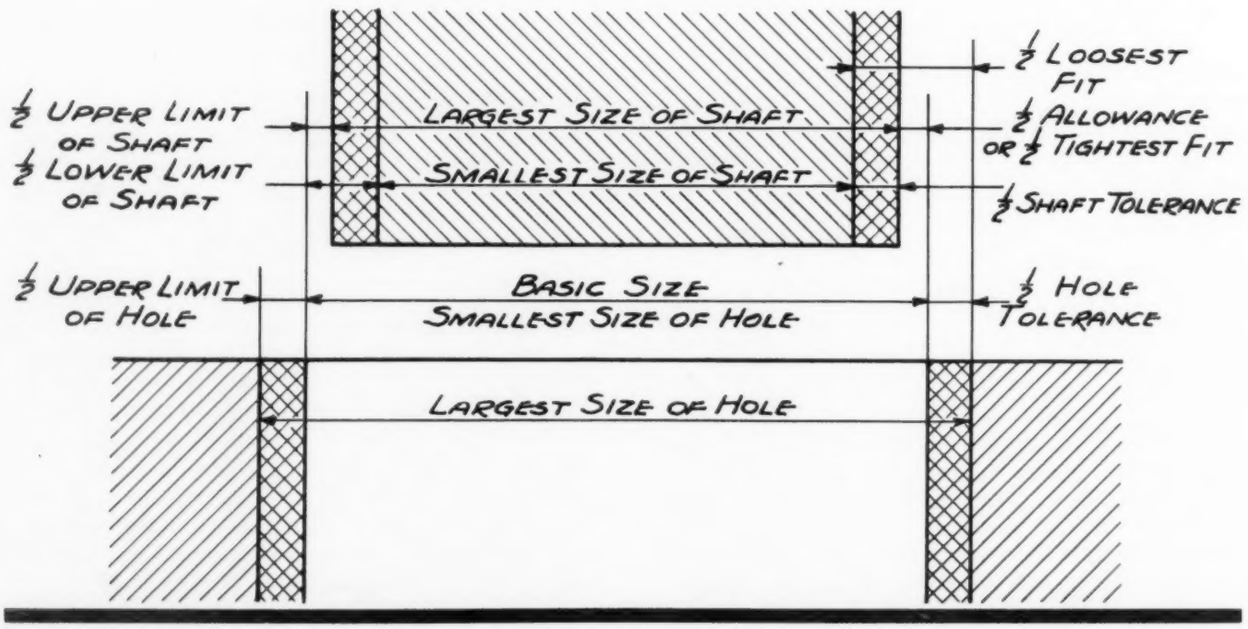
Roller bearing fits.
Ingot mould axles.
Plate mill leveler rolls.
42 in. cold mill pinch rolls.
Diesel locomotive axles.

STANDARDS OF FIT

After studying the available literature, the Committee decided to follow as closely as possible, the tentative American Standard 1925: "Tolerances and Allowances and Gauges for Metal Fits." The reasons for this decision were, that this standard called hereafter ASA Standard, is an orderly attack on the general problem of tolerance and fits and because reamers and gauges for the various classes of fit are available in this country. Before any discussion of the subject of fits is possible, it is necessary to agree on certain basic definitions of terms. Below are these terms as defined by the ASA and shown as Figure 2 and 3.

Basic size—The ASA Standards are basic hole standards, that is, the smallest allowable size of the hole is the basis from which other measurements are made.

FIGURE 2—Diagram showing standardized terminology of running fits, with shaft smaller than hole, and positive allowance.


½ LOOSEST FIT
½ UPPER LIMIT OF SHAFT
LARGEST SIZE OF SHAFT
½ ALLOWANCE OR ½ TIGHTEST FIT
½ LOWER LIMIT OF SHAFT
SMALLEST SIZE OF SHAFT
½ SHAFT TOLERANCE
½ UPPER LIMIT OF HOLE
BASIC SIZE
SMALLEST SIZE OF HOLE
½ HOLE TOLERANCE
LARGEST SIZE OF HOLE

Allowance—The intentional difference between the sizes of mating parts. This is the minimum clearance in a "running fit" and maximum tightness in a press fit. It is the difference between the largest allowed shaft size and the minimum hole size. It is considered positive (+) when the shaft is smaller than the hole and negative (—) when the shaft is larger than the hole.

Tolerance—Amount of variations permitted in the size of a part. There is no such thing as making "exactly to size" and the less the tolerance, the more expensive the part. Tolerances are given from .000 to (+) or .000 to (—) never from (—) to (+), that is, they are unilateral.

Limits—The extreme permissable dimensions of a part. The upper limit of a hole is equal to the tolerance in a basic hole system. The lower limit is .000.

Loosest fit —The sum of the allowance and the tolerances on both the mating parts.

Average fit —The average of the loosest and tightest fit. This is not part of the ASA Standard.

Adjusted fit—This fit was added to the ASA Standards to take care of the condition that so frequently arises in maintenance where the shaft or hole is partly worn and the size of mating part is adjusted to give the desired fit. The limits given were arrived at by adding ½ the tolerance to the average fit, and subtracting ½ the tolerance from the average fit. The measured size of the given part is the basis from which the limits are taken.

Class of Fit

The class of a fit is based on the allowance or the intentional difference between the mating parts. The ASA has eight classes of fit of which this standard uses five. Since the ASA fits were all too close for some work around the mill table, another fit called a clearance fit has been calculated and added. The ASA developed formulae for the relation of tolerance and allowance to diameter, and these are perhaps the best description of the class. (See Table 1)

Methods of Assembly

The ASA lists the class 1 and 3 fits as strictly interchangeable, that is, that any shaft made within the limits shown would work satisfactorily with any hole made within the limits shown, clearly the clearance fit would be in that same category. The ASA lists the classes 5, 7 and 8 as being assembled by selection. They have provided a "selected fit". After a number of shafts and a number of holes have been made within the limits, the larger shafts are matched with the larger holes and the smaller shafts with the smaller holes to give an average or selected fit. In most cases for our work the three last fits can be considered interchangeable, also and a closer fit can be obtained by making one part, preferably the hole, measuring it, then using the adjusted fit.

Explanation of Tables of Fits

To show the use of the table, take a class 1 fit: Suppose the nominal size is $4\frac{1}{8}$ or 4.125.

FIGURE 3—Diagram showing standardized terminology of tight fits, with shaft larger than hole, and negative allowance.

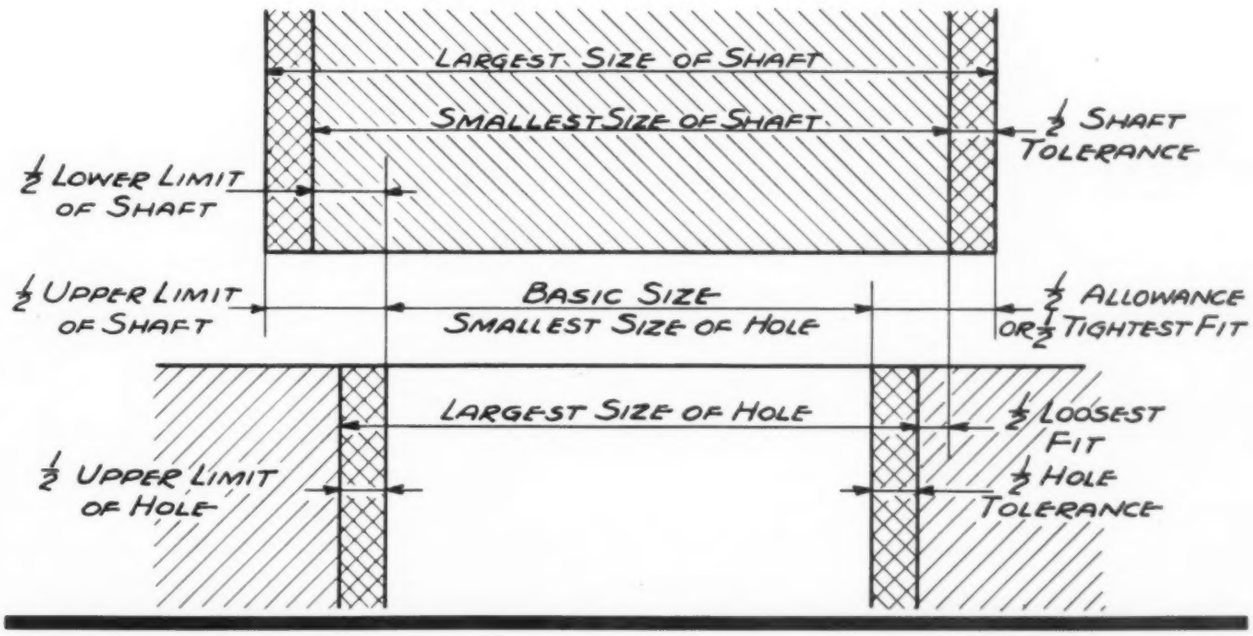

LARGEST SIZE OF SHAFT
SMALLEST SIZE OF SHAFT
½ SHAFT TOLERANCE
½ LOWER LIMIT OF SHAFT
½ UPPER LIMIT OF SHAFT
BASIC SIZE
SMALLEST SIZE OF HOLE
½ ALLOWANCE OR ½ TIGHTEST FIT
LARGEST SIZE OF HOLE
½ LOOSEST FIT
½ HOLE TOLERANCE
½ UPPER LIMIT OF HOLE

TABLE I

Class	Allowance	Selected Interference of metal	Hole tolerance	Shaft tolerance
Clearance fit	$.007\sqrt{d^2}$		$.006\sqrt[3]{d}$	
1—Running fit	$.0025\sqrt[3]{d^2}$		$.0025\sqrt[3]{d}$	$.0025\sqrt{d}$
3—Close running fit	$.0009\sqrt[3]{d^2}$		$.0008\sqrt[3]{d}$	$.0008\sqrt{d}$
5—Size and size fit		.000 d	$.0006\sqrt[3]{d}$	$.0006\sqrt{d}$
7—Medium force fit		.0005 d	$.0006\sqrt[3]{d}$	$.006\sqrt{d}$
8—Press and shrink fit		.001 d	$.0006\sqrt[3]{d}$	$.0006\sqrt{d}$

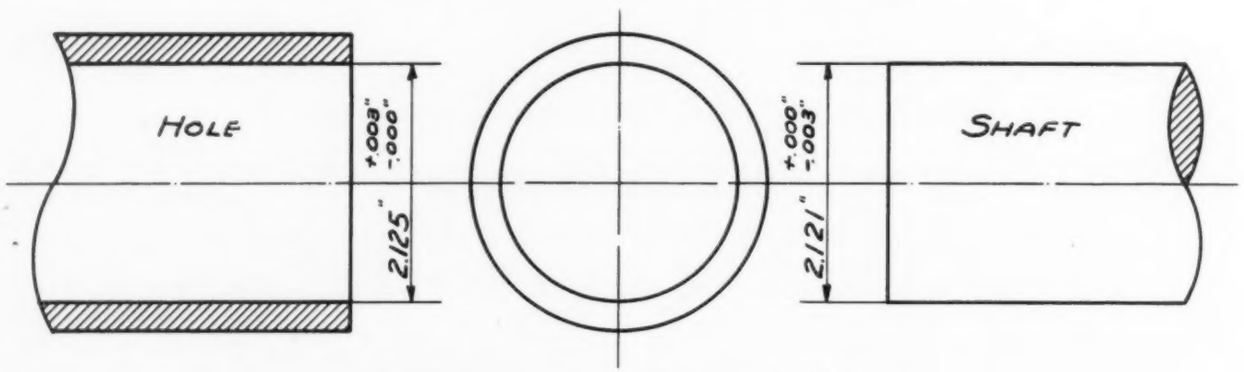
This is between $3\frac{3}{4}$ and $4\frac{1}{4}$.
Limits on the hole are + .004 and — .000 written
$4.125\begin{cases}-.000\\+.004\end{cases}$
The tolerance is the .004
The hole then will be any diameter between 4.125 and 4.129
The shaft limits are — .006 to — .010 or
The tolerance is (— .006) — (— .010) = .004
The largest size of shaft . . . . . 4.125 — .006 or 4.119
The smallest size of shaft . . . . . 4.125 — .010 or 4.115
The shaft dimension is written $4.119\begin{cases}+0.000\\-0.004\end{cases}$

A new $4\frac{1}{8}$ shaft of a class 1 fit would be made $4.119\begin{cases}+0.000\\-0.004\end{cases}$ and the hole would be made $4.125\begin{cases}+0.004\\-0.000\end{cases}$

Note—In the case of the new shaft, the smallest hole is 4.125 and the largest shaft is 4.119, the allowance or tightest fit is 4.125—4.119 or .006. The largest hole is 4.129 and the smallest shaft 4.115, the loosest fit is 4.129 —4.115 or 0.014.

Suppose the shaft is returned to the shop, worn rather badly to have a new brass fitted. After truing up, it is

FIGURE 4—Sketch showing example of class 1 fit, giving allowances and method of indicating them on drawing.



EXAMPLE OF CLASS 1 FIT

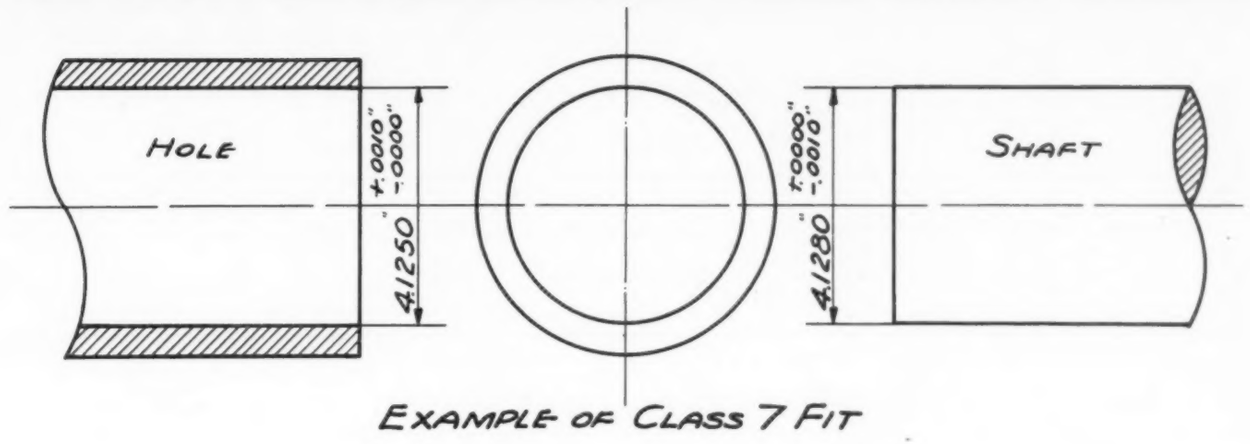


FIGURE 5—Sketch of example of class 7 fit, showing method of indicating allowances on drawing.

found that the diameter is now 4.083. Under "adjusted fit"—shaft given the hole limits are + 0.012 and + 0.008. The hole should fall between 4.083 + .008 or 4.091, and 4.083 + 0.012 or 4.095. This would be written in instructions to men or records:

$$4.091 \begin{cases} + 0.004 \\ - 0.000 \end{cases}$$

Now take a medium force fit class 7:
Again let us use a 4⅛ in. or 4.125 shaft
The hole size will be 4.125 — .000 to 4.125 + 0.001

or $4.125 \begin{cases} + 0.001 \\ - 0.000 \end{cases}$. This time the shaft is larger than the hole.

Clearance Fit
To suit scale measurements

Size		Limits			Tightest fit	Loosest fit		Adjusted fit			
From	Up to and incl.	Hole (1)	Shaft		Allowance	Allowance + Tolerance	Average fit	Shaft given hole limits		Hole given shaft limits	
	—	+	—	—	+	+	+	+	+	—	—
½	1½	0.008	0.008	0.016	0.008	0.023	0.016	0.023	0.016	0.016	0.023
1½	2½	0.008	0.016	0.023	0.016	0.031	0.023	0.023	0.016	0.016	0.023
2½	3½	0.008	0.016	0.023	0.016	0.031	0.023	0.031	0.023	0.023	0.031
3½	4½	0.008	0.023	0.031	0.023	0.039	0.031	0.031	0.023	0.023	0.031
4½	5½	0.008	0.023	0.031	0.023	0.039	0.031	0.031	0.023	0.023	0.031
5½	8½	0.016	0.023	0.039	0.023	0.055	0.039	0.047	0.031	0.031	0.047
8½	10½	0.016	0.031	0.047	0.031	0.063	0.047	0.055	0.039	0.039	0.055
10½	13½	0.016	0.039	0.055	0.039	0.070	0.055	0.063	0.047	0.047	0.063
13½	16½	0.016	0.047	0.063	0.047	0.078	0.063	0.070	0.055	0.055	0.070
16½	21½	0.016	0.055	0.070	0.055	0.087	0.070	0.079	0.063	0.063	0.079
21½	26½	0.016	0.055	0.070	0.055	0.087	0.070	0.079	0.063	0.063	0.079

The greatest accuracy in measurement required is ½ of $\frac{1}{10}$ of an inch.
Use: Mill table rollers and other parts where temperature and misalignment are factors.
(1) Since this is a basic hole system bottom limit of hole is always 0.0000.

It varies from 4.125 + 0.002 to 4.125 + 0.003 or $4.128\begin{cases}+\ 0.000\\-\ 0.001\end{cases}$

Suppose then the shaft is returned to the shop and trued up. Its dimension is then found to be 4.083 under class "adjusted fit"—shaft given, hole limits are — .0016 and — .0025. The hole then would be bored 4.083 — .0025 or 4.0805 to 4.083 — .0016 or 4.0814. This would be written $4.0805\begin{cases}+\ .0009\\-\ .000\end{cases}$

Class 1 Fit
Running fit

Size		Limits			Tightest fit	Loosest fit		Adjusted fit			
From	Up to and incl.	Hole (1)	Shaft		Allowance	Allowance + Tolerance	Average fit	Shaft given hole limits		Hole given shaft limits	
		+	—	—	+(2)	+(2)		+	+	—	—
0	3/16	0.001	0.001	0.002	0.001	0.003	0.002	0.003	0.002	0.002	0.003
3/16	5/16	0.002	0.001	0.003	0.001	0.005	0.003	0.004	0.002	0.002	0.004
5/16	7/16	0.002	0.001	0.003	0.001	0.005	0.003	0.004	0.002	0.002	0.004
7/16	9/16	0.002	0.002	0.004	0.002	0.006	0.004	0.005	0.003	0.003	0.005
9/16	11/16	0.002	0.002	0.004	0.002	0.006	0.004	0.005	0.003	0.003	0.005
11/16	13/16	0.002	0.002	0.004	0.002	0.006	0.004	0.005	0.003	0.003	0.005
13/16	15/16	0.002	0.002	0.004	0.002	0.006	0.004	0.005	0.003	0.003	0.005
15/16	1 1/16	0.003	0.003	0.006	0.003	0.009	0.006	0.008	0.005	0.005	0.008
1 1/16	1 3/16	0.003	0.003	0.006	0.003	0.009	0.006	0.008	0.005	0.005	0.008
1 3/16	1 3/8	0.003	0.003	0.006	0.003	0.009	0.006	0.008	0.005	0.005	0.008
1 3/8	1 5/8	0.003	0.003	0.006	0.003	0.009	0.006	0.008	0.005	0.005	0.008
1 5/8	1 7/8	0.003	0.004	0.007	0.004	0.010	0.007	0.009	0.006	0.006	0.009
1 7/8	2 1/8	0.003	0.004	0.007	0.004	0.010	0.007	0.009	0.006	0.006	0.009
2 1/8	2 3/8	0.003	0.004	0.007	0.004	0.010	0.007	0.009	0.006	0.006	0.009
2 3/8	2 3/4	0.003	0.005	0.008	0.005	0.011	0.008	0.010	0.007	0.007	0.010
2 3/4	3 1/4	0.004	0.005	0.009	0.005	0.013	0.009	0.011	0.007	0.007	0.011
3 1/4	3 3/4	0.004	0.006	0.010	0.006	0.014	0.010	0.012	0.008	0.008	0.012
3 3/4	4 1/4	0.004	0.006	0.010	0.006	0.014	0.010	0.012	0.008	0.008	0.012
4 1/4	4 3/4	0.004	0.007	0.011	0.007	0.015	0.011	0.013	0.009	0.009	0.013
4 3/4	5 1/2	0.004	0.007	0.011	0.007	0.015	0.011	0.013	0.009	0.009	0.013
5 1/2	6 1/2	0.005	0.008	0.013	0.008	0.018	0.013	0.015	0.010	0.010	0.015
6 1/2	7 1/2	0.005	0.009	0.014	0.009	0.019	0.014	0.017	0.012	0.012	0.017
7 1/2	8 1/2	0.005	0.010	0.015	0.010	0.020	0.015	0.018	0.013	0.013	0.018
8 1/2	9 1/2	0.005	0.011	0.016	0.011	0.021	0.016	0.019	0.014	0.014	0.019
9 1/2	11 1/2	0.005	0.012	0.017	0.012	0.022	0.017	0.020	0.015	0.015	0.020
11 1/2	13	0.006	0.013	0.019	0.013	0.025	0.019	0.022	0.016	0.016	0.022
13	15	0.006	0.015	0.021	0.015	0.027	0.021	0.024	0.018	0.018	0.024
15	17	0.006	0.016	0.022	0.016	0.028	0.022	0.025	0.019	0.019	0.025
17	19	0.007	0.017	0.024	0.017	0.031	0.024	0.028	0.021	0.021	0.028
19	22	0.007	0.018	0.025	0.018	0.032	0.025	0.029	0.022	0.022	0.029
22	26	0.007	0.021	0.028	0.021	0.035	0.028	0.032	0.025	0.025	0.032
26	30	0.008	0.023	0.031	0.023	0.039	0.031	0.035	0.027	0.027	0.035
30	34	0.008	0.024	0.032	0.024	0.040	0.032	0.036	0.028	0.028	0.036

Use: Average machine work as roller leveler journals, nail machinery.
(1) Since this is a basic hole system bottom limit of hole is always 0.0000.
(2) Denotes clearance or amount of looseness.

Conclusion

It will require a great deal of time and a great deal of effort to make these standards work. If, as is easily possible, the standards require revision, this can be accomplished by the addition of finer finishes and coarser and finer classes of fit. The procedure for application is suggested.

1—All new drawings to be marked with proper tolerance and finish marks.

2—Repeat work such as table rollers, etc. in the machine shop to be listed as to class of fit and

Class 3 Fit
Close running fit

Size		Limits			Tightest fit	Loosest fit		Adjusted fit			
From	Up to and incl.	Hole (1)	Shaft		Allowance	Allowance + Tolerance	Average fit	Shaft given hole limits		Hole given shaft limits	
		+	—	—	+(2)	+(2)		+	+	—	—
0	3/16	0.0004	0.0002	0.0006	0.0002	0.0010	0.0006	0.0008	0.0004	0.0004	0.0008
3/16	5/16	0.0005	0.0004	0.0009	0.0004	0.0014	0.0009	0.0012	0.0007	0.0007	0.0012
5/16	7/16	0.0006	0.0005	0.0011	0.0005	0.0017	0.0011	0.0014	0.0008	0.0008	0.0014
7/16	9/16	0.0006	0.0006	0.0012	0.0006	0.0018	0.0012	0.0015	0.0009	0.0009	0.0015
9/16	11/16	0.0007	0.0007	0.0014	0.0007	0.0021	0.0014	0.0018	0.0011	0.0011	0.0018
11/16	13/16	0.0007	0.0007	0.0014	0.0007	0.0021	0.0014	0.0018	0.0011	0.0011	0.0018
13/16	15/16	0.0008	0 0008	0.0016	0.0008	0.0024	0.0016	0.0020	0.0012	0.0012	0.0020
15/16	1 1/16	0.0008	0.0009	0.0017	0.0009	0.0025	0.0017	0.0021	0.0013	0.0013	0.0021
1 1/16	1 3/16	0.0008	0.0010	0.0018	0.0010	0.0026	0.0018	0.0022	0.0014	0.0014	0.0022
1 3/16	1 3/8	0.0009	0.0010	0.0019	0.0010	0.0028	0.0019	0.0024	0.0015	0.0015	0.0024
1 3/8	1 5/8	0.0009	0.0012	0.0021	0.0012	0.0030	0.0021	0.0026	0.0017	0.0017	0.0026
1 5/8	1 7/8	0.0010	0.0013	0.0023	0.0013	0.0033	0.0023	0.0028	0.0018	0.0018	0.0028
1 7/8	2 1/8	0.0010	0.0014	0.0024	0.0014	0.0034	0.0024	0.0029	0.0019	0.0019	0.0029
2 1/8	2 3/8	0.0010	0.0015	0.0025	0.0015	0.0035	0.0025	0.0030	0.0020	0.0020	0.0030
2 3/8	2 3/4	0.0011	0.0017	0.0028	0.0017	0.0039	0.0028	0.0034	0.0023	0.0023	0.0034
2 3/4	3 1/4	0.0012	0.0019	0.0031	0.0019	0.0043	0.0031	0.0037	0.0025	0.0025	0.0037
3 1/4	3 3/4	0.0012	0.0021	0.0033	0.0021	0.0045	0.0033	0.0039	0.0027	0.0027	0.0039
3 3/4	4 1/4	0.0013	0.0023	0.0036	0.0023	0.0049	0.0036	0.0043	0.0030	0.0030	0.0043
4 1/4	4 3/4	0.0013	0.0025	0.0038	0.0025	0.0051	0.0038	0.0045	0.0032	0.0032	0.0045
4 3/4	5 1/2	0.0014	0.0026	0.0040	0.0026	0.0054	0.0040	0.0047	0.0033	0.0033	0.0047
5 1/2	6 1/2	0.0015	0.0030	0.0045	0.0030	0.0060	0.0045	0.0053	0.0038	0.0038	0.0053
6 1/2	7 1/2	0.0015	0.0033	0.0048	0.0033	0.0063	0.0048	0.0056	0.0041	0.0041	0.0056
7 1/2	8 1/2	0.0016	0.0036	0.0052	0.0036	0.0068	0.0052	0.0060	0.0044	0.0044	0.0060
8 1/2	9 1/2	0.0017	0.0039	0.0056	0.0039	0.0073	0.0056	0.0065	0.0048	0.0048	0.0065
9 1/2	11 1/2	0.0017	0.0042	0.0059	0.0042	0.0076	0.0059	0.0068	0.0051	0.0051	0.0068
11 1/2	13	0.0018	0.0047	0.0065	0.0047	0.0083	0.0065	0.0074	0.0056	0.0056	0.0074
13	15	0.0019	0.0052	0.0071	0.0052	0.0090	0.0071	0.0081	0.0062	0.0062	0.0081
15	17	0.0020	0.0057	0.0077	0.0057	0.0097	0.0077	0.0087	0.0067	0.0067	0.0087
17	19	0.0021	0.0062	0.0083	0.0062	0.0103	0.0083	0.0094	0.0073	0.0073	0.0094
19	22	0.0022	0.0066	0.0088	0.0066	0.0110	0.0088	0.0099	0.0077	0.0077	0.0099
22	26	0.0023	0.0075	0.0098	0.0075	0.0121	0.0098	0.0110	0.0087	0.0087	0.0110
26	30	0.0024	0.0083	0.0107	0.0083	0.0131	0.0107	0.0119	0.0095	0.0095	0.0119
30	34	0.0025	0.0091	0.0116	0.0091	0.0141	0.0116	0.0129	0.0104	0.0104	0.0129

Use: For running fits under 600 rpm. and more accurate machine parts. Mostly tool room work.
(1) Since this is a basic hole system bottom limit of hole is always 0.0000.
(2) Denotes clearance or amount of looseness.

finish. The shop then to apply the new tables.

3—Gradual correction of older drawings after complete survey of separate units.

4—Extend the use of gauges for the smaller sizes.

5—Systematize the checking of micrometers for accuracy.

6—Carry on continuously a program of education of foremen and apprentices.

7—Improve system for recording changes in a particular part.

Miscellaneous Fit

On a drawing that is marked for tolerance and fits, dimensions between finished surfaces that are not

Class 5—Size and Size Fit

Size			Limits		Tightest fit	Loosest fit		Adjusted fit			
From	Up to and incl.	Hole (1)	Shaft		Allowance	Allowance + Tolerance	Selected fit	Shaft given hole limits		Hole given shaft limits	
		+	+		—(2)	+(2)		+	—	+	—
0	3/16	0.0003	0.0002	0.0000	0.0002	0.0003	0.0000	0.0002	0.0002	0.0002	0.0002
3/16	5/16	0.0004	0.0003	0.0000	0.0003	0.0004	0.0000	0.0002	0.0002	0.0002	0.0002
5/16	7/16	0.0004	0.0003	0.0000	0.0003	0.0004	0.0000	0.0002	0.0002	0.0002	0.0002
7/16	9/16	0.0005	0.0003	0.0000	0.0003	0.0005	0.0000	0.0003	0.0002	0.0002	0.0003
9/16	11/16	0.0005	0.0003	0.0000	0.0003	0.0005	0.0000	0.0003	0.0002	0.0002	0.0003
11/16	13/16	0.0005	0.0004	0.0000	0.0004	0.0005	0.0000	0.0003	0.0002	0.0002	0.0003
13/16	15/16	0.0006	0.0004	0.0000	0.0004	0.0006	0.0000	0.0003	0.0003	0.0003	0.0003
15/16	1 1/16	0.0006	0.0004	0.0000	0.0004	0.0006	0.0000	0.0003	0.0003	0.0003	0.0003
1 1/16	1 3/16	0.0006	0.0004	0.0000	0.0004	0.0006	0.0000	0.0003	0.0003	0.0003	0.0003
1 3/16	1 3/8	0.0006	0.0004	0.0000	0.0004	0.0006	0.0000	0.0003	0.0003	0.0003	0.0003
1 3/8	1 5/8	0.0007	0.0005	0.0000	0.0005	0.0007	0.0000	0.0004	0.0003	0.0003	0.0004
1 5/8	1 7/8	0.0007	0.0005	0.0000	0.0005	0.0007	0.0000	0.0004	0.0003	0.0003	0.0004
1 7/8	2 1/8	0.0008	0.0005	0.0000	0.0005	0.0008	0.0000	0.0004	0.0004	0.0004	0.0004
2 1/8	2 3/8	0.0008	0.0005	0.0000	0.0005	0.0008	0.0000	0.0004	0.0004	0.0004	0.0004
2 3/8	2 3/4	0.0008	0.0005	0.0000	0.0005	0.0008	0.0000	0.0004	0.0004	0.0004	0.0004
2 3/4	3 1/4	0.0009	0.0006	0.0000	0.0006	0.0009	0.0000	0.0005	0.0004	0.0004	0.0005
3 1/4	3 3/4	0.0009	0.0006	0.0000	0.0006	0.0009	0.0000	0.0005	0.0004	0.0004	0.0005
3 3/4	4 1/4	0.0010	0.0006	0.0000	0.0006	0.0010	0.0000	0.0005	0.0005	0.0005	0.0005
4 1/4	4 3/4	0.0010	0.0007	0.0000	0.0007	0.0010	0.0000	0.0005	0.0005	0.0005	0.0005
4 3/4	5 1/2	0.0010	0.0007	0.0000	0.0007	0.0010	0.0000	0.0005	0.0005	0.0005	0.0005
5 1/2	6 1/2	0.0011	0.0007	0.0000	0.0007	0.0011	0.0000	0.0006	0.0005	0.0005	0.0006
6 1/2	7 1/2	0.0011	0.0008	0.0000	0.0008	0.0011	0.0000	0.0006	0.0005	0.0005	0.0006
7 1/2	8 1/2	0.0012	0.0008	0.0000	0.0008	0.0012	0.0000	0.0006	0.0006	0.0006	0.0006
8 1/2	9 1/2	0.0012	0.0008	0.0000	0.0008	0.0012	0.0000	0.0006	0.0006	0.0006	0.0006
9 1/2	11 1/2	0.0013	0.0009	0.0000	0.0009	0.0013	0.0000	0.0007	0.0006	0.0006	0.0007
11 1/2	13	0.0014	0.0009	0.0000	0.0009	0.0014	0.0000	0.0007	0.0007	0.0007	0.0007
13	15	0.0014	0.0010	0.0000	0.0010	0.0014	0.0000	0.0007	0.0007	0.0007	0.0007
15	17	0.0015	0.0010	0.0000	0.0010	0.0015	0.0000	0.0008	0.0007	0.0007	0.0008
17	19	0.0016	0.0011	0.0000	0.0011	0.0016	0.0000	0.0008	0.0008	0.0008	0.0008
19	22	0.0016	0.0012	0.0000	0.0012	0.0016	0.0000	0.0008	0.0008	0.0008	0.0008
22	26	0.0017	0.0012	0.0000	0.0012	0.0017	0.0000	0.0009	0.0008	0.0008	0.0009
26	30	0.0018	0.0012	0.0000	0.0012	0.0018	0.0000	0.0009	0.0009	0.0009	0.0009
30	34	0.0019	0.0013	0.0000	0.0013	0.0019	0.0000	0.0010	0.0009	0.0009	0.0010

Use: Large size fitted bolts; some line shaft coupling and gear fits.
(1) Since this is a basic hole system bottom limit of hole is always 0.0000.
(2) (—) Denotes interference of metal or negative allowance.
(+) Denotes clearance or amount of looseness.

marked in decimals are considered to be + 0.000 and — 0.016. for external dimensions and + .016 and — .000 for internal dimensions, up to and including 24 in., beyond this the internal dimensions to be + 0.032 and — .000.

The external to be + .000 and — .032.

All roller bearing fit dimensions and tolerances are to be taken from the manufacturers catalogue.

Class 7—Medium Force Fit

Size		Limits			Tightest fit	Loosest fit		Adjusted fit			
From	Up to and incl.	Hole (1)	Shaft		Allowance	Allowance + Tolerance	Selected fit	Shaft given hole limits		Hole given shaft limits	
		+	+	+	—(2)	(2)	—(2)		—	+	
0	3/16	0.0003	0.0004	0.0001	0.0004	+ .0002	0.0001	+ .0001	0.0002	0.0002	— .0001
3/16	5/16	0.0004	0.0005	0.0001	0.0005	+ .0003	0.0001	+ .0001	0.0003	0.0003	— .0001
5/16	7/16	0.0004	0.0006	0.0002	0.0006	+ .0002	0.0002	0.0000	0.0004	0.0004	0.0000
7/16	9/16	0.0005	0.0008	0.0003	0.0008	+ .0002	0.0003	0.0000	0.0005	0.0005	0.0000
9/16	11/16	0.0005	0.0008	0.0003	0.0008	+ .0002	0.0003	0.0000	0.0005	0.0005	0.0000
11/16	13/16	0.0005	0.0009	0.0004	0.0009	+ .0001	0.0004	— .0001	0.0006	0.0006	+ .0001
13/16	15/16	0.0006	0.0010	0.0004	0.0010	+ .0002	0.0004	— .0002	0.0007	0.0007	+ .0002
15/16	1 1/16	0.0006	0.0011	0.0005	0.0011	+ .0001	0.0005	— .0002	0.0008	0.0008	+ .0002
1 1/16	1 3/16	0.0006	0.0012	0.0006	0.0012	0.0000	0.0006	— .0003	0.0009	0.0009	+ .0003
1 3/16	1 3/8	0.0006	0.0012	0.0006	0.0012	0.0000	0.0006	— .0003	0.0009	0.0009	+ .0003
1 3/8	1 5/8	0.0007	0.0015	0.0008	0.0015	— .0001	0.0008	— .0005	0.0012	0.0012	+ .0005
1 5/8	1 7/8	0.0007	0.0016	0.0009	0.0016	— .0002	0.0009	— .0006	0.0013	0.0013	+ .0006
1 7/8	2 1/8	0.0008	0.0018	0.0010	0.0018	— .0002	0.0010	— .0006	0.0014	0.0014	+ .0006
2 1/8	2 3/8	0.0008	0.0019	0.0011	0.0019	— .0003	0.0011	— .0007	0.0015	0.0015	+ .0007
2 3/8	2 3/4	0.0008	0.0021	0.0013	0.0021	— .0005	0.0013	— .0009	0.0017	0.0017	+ .0009
2 3/4	3 1/4	0.0009	0.0024	0.0015	0.0024	— .0006	0.0015	— .0011	0.0020	0.0020	+ .0011
3 1/4	3 3/4	0.0009	0.0027	0.0018	0.0027	— .0009	0.0018	— .0014	0.0023	0.0023	+ .0014
3 3/4	4 1/4	0.0010	0.0030	0.0020	0.0030	— .0010	0.0020	— .0016	0.0025	0.0025	+ .0016
4 1/4	4 3/4	0.0010	0.0033	0.0023	0.0033	— .0013	0.0023	— .0018	0.0028	0.0028	+ .0018
4 3/4	5 1/2	0.0010	0.0035	0.0025	0.0035	— .0015	0.0025	— .0020	0.0030	0.0030	+ .0020
5 1/2	6 1/2	0.0011	0.0041	0.0031	0.0041	— .0019	0.0030	— .0025	0.0036	0.0036	+ .0025
6 1/2	7 1/2	0.0011	0.0046	0.0035	0.0046	— .0024	0.0035	— .0030	0.0041	0.0041	+ .0030
7 1/2	8 1/2	0.0012	0.0052	0.0040	0.0052	— .0028	0.0040	— .0034	0.0046	0.0046	+ .0034
8 1/2	9 1/2	0.0012	0.0057	0.0045	0.0057	— .0033	0.0045	— .0039	0.0051	0.0051	+ .0039
9 1/2	11 1/2	0.0013	0.0063	0.0050	0.0063	— .0037	0.0050	— .0044	0.0057	0.0057	+ .0044
11 1/2	13	0.0014	0.0074	0.0060	0.0074	— .0046	0.0060	— .0053	0.0067	0.0067	+ .0053
13	15	0.0014	0.0084	0.0070	0.0084	— .0056	0.0070	— .0063	0.0077	0.0077	+ .0063
15	17	0.0015	0.0095	0.0080	0.0095	— .0065	0.0080	— .0073	0.0088	0.0088	+ .0073
17	19	0.0016	0.0106	0.0090	0.0106	— .0074	0.0090	— .0082	0.0098	0.0098	+ .0082
19	22	0.0016	0.0116	0.0100	0.0116	— .0084	0.0100	— .0092	0.0108	0.0108	+ .0092
22	26	0.0017	0.0137	0.0120	0.0137	— .0103	0.0120	— .0112	0.0129	0.0129	+ .0112
26	30	0.0018	0.0158	0.0140	0.0158	— .0122	0.0140	— .0131	0.0149	0.0149	+ .0131
30	34	0.0019	0.0179	0.0160	0.0179	— .0141	0.0160	— .0151	0.0170	0.0170	+ .0151

(1) Since this is a basic hole system bottom limit of hole is always 0.0000.
(2) (—) Denotes interference of metal or negative allowance.
(+) Denotes clearance or amount of looseness.
Use: Tightest fit for cast iron hub on steel shaft.

Class 8—Press and Shrink Fit

Size		Limits			Tightest fit	Loosest fit		Adjusted fit			
From	Up to and incl.	Hole (1)	Shaft		Allowance	Allowance + Tolerance	Selected fit	Shaft given hole limits		Hole given shaft limits	
		+	+	+	—(2)	(2)	—(2)	—	—	+	+
0	3/16	0.0003	0.0004	0.0001	0.0004	.0002	0.0001	0.0000	0.0003	0.0003	0.0000
3/16	5/16	0.0004	0.0007	0.0003	0.0007	.0001	0.0003	0.0001	0.0003	0.0003	0.0001
5/16	7/16	0.0004	0.0008	0.0004	0.0008	0.0000	0.0004	0.0002	0.0006	0.0006	0.0002
7/16	9/16	0.0005	0.0010	0.0005	0.0010	0.0000	0.0005	0.0003	0.0008	0.0008	0.0003
9/16	11/16	0.0005	0.0011	0.0006	0.0011	—.0001	0.0006	0.0004	0.0009	0.0009	0.0004
11/16	13/16	0.0005	0.0013	0.0008	0.0013	—.0003	0.0008	0.0006	0.0011	0.0011	0.0006
13/16	15/16	0.0006	0.0015	0.0009	0.0015	—.0003	0.0009	0.0006	0.0012	0.0012	0.0006
15/16	1 1/16	0.0006	0.0016	0.0010	0.0016	—.0004	0.0010	0.0007	0.0013	0.0013	0.0007
1 1/16	1 3/16	0.0006	0.0017	0.0011	0.0017	—.0005	0.0011	0.0008	0.0014	0.0014	0.0008
1 3/16	1 3/8	0.0006	0.0019	0.0013	0.0019	—.0007	0.0013	0.0010	0.0016	0.0016	0.0010
1 3/8	1 5/8	0.0007	0.0022	0.0015	0.0022	—.0008	0.0015	0.0012	0.0019	0.0019	0.0012
1 5/8	1 7/8	0.0007	0.0025	0.0018	0.0025	—.0011	0.0018	0.0015	0.0022	0.0022	0.0015
1 7/8	2 1/8	0.0008	0.0028	0.0020	0.0028	—.0012	0.0020	0.0016	0.0024	0.0024	0.0016
2 1/8	2 3/8	0.0008	0.0031	0.0023	0.0031	—.0015	0.0023	0.0019	0.0027	0.0027	0.0019
2 3/8	2 3/4	0.0008	0.0033	0.0025	0.0033	—.0017	0.0025	0.0021	0.0029	0.0029	0.0021
2 3/4	3 1/4	0.0009	0.0039	0.0030	0.0039	—.0021	0.0030	0.0026	0.0035	0.0035	0.0026
3 1/4	3 3/4	0.0009	0.0044	0.0035	0.0044	—.0026	0.0035	0.0031	0.0040	0.0040	0.0031
3 3/4	4 1/4	0.0010	0.0050	0.0040	0.0050	—.0030	0.0040	0.0035	0.0045	0.0045	0.0035
4 1/4	4 3/4	0.0010	0.0055	0.0045	0.0055	—.0035	0.0045	0.0040	0.0050	0.0050	0.0040
4 3/4	5 1/2	0.0010	0.0060	0.0050	0.0060	—.0040	0.0050	0.0045	0.0055	0.0055	0.0045
5 1/2	6 1/2	0.0011	0.0071	0.0060	0.0071	—.0049	0.0060	0.0055	0.0066	0.0066	0.0055
6 1/2	7 1/2	0.0011	0.0081	0.0070	0.0081	—.0059	0.0070	0.0065	0.0076	0.0076	0.0065
7 1/2	8 1/2	0.0012	0.0092	0.0080	0.0092	—.0068	0.0080	0.0074	0.0086	0.0086	0.0074
8 1/2	9 1/2	0.0012	0.0102	0.0090	0.0102	—.0078	0.0090	0.0084	0.0096	0.0096	0.0084
9 1/2	11 1/2	0.0013	0.0113	0.0100	0.0113	—.0087	0.0100	0.0094	0.0107	0.0107	0.0094
11 1/2	13	0.0014	0.0134	0.0120	0.0134	—.0106	0.0120	0.0113	0.0127	0.0127	0.0113
13	15	0.0014	0.0154	0.0140	0.0154	—.0126	0.0140	0.0133	0.0147	0.0147	0.0133
15	17	0.0015	0.0175	0.0160	0.0175	—.0145	0.0160	0.0153	0.0168	0.0168	0.0153
17	19	0.0016	0.0196	0.0180	0.0196	—.0164	0.0180	0.0172	0.0188	0.0188	0.0172
19	22	0.0016	0.0216	0.0200	0.0216	—.0184	0.0200	0.0192	0.0208	0.0208	0.0192
22	26	0.0017	0.0257	0.0240	0.0257	—.0223	0.0240	0.0232	0.0249	0.0249	0.0232
26	30	0.0018	0.0298	0.0280	0.0298	—.0262	0.0280	0.0271	0.0289	0.0289	0.0271
30	34	0.0019	0.0339	0.0320	0.0339	—.0301	0.0320	0.0311	0.0330	0.0330	0.0311

(1) Since this is a basic hole system bottom limit of hole is always 0 0000.
(2) (—) Denotes interference of metal or negative allowance.
(+) Denotes clearance or amount of looseness.
Use: Tightest fit for steel shaft and steel hub.

DISCUSSION

PRESENTED BY

A. T. HALSTEAD, Mill Master Mechanic, Bethlehem Steel Company, Sparrows Point, Maryland.

F. C. SCHOEN, Assistant to Plant Engineer, Midvale Nicetown, Philadelphia, Pennsylvania.

G. C. PFEFFER, Superintendent of Power, Florence Pipe Foundry and Machine Company, Florence, New Jersey.

W. J. REA, Assistant Superintendent of Maintenance, Bethlehem Steel Company, Bethlehem, Pennsylvania.

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.

L. J. GOULD, Assistant Chief Engineer of Construction, Bethlehem Steel Company, Bethlehem Pennsylvania.

A. T. HALSTEAD: I do not have anything to add to Mr. Gould's paper, except to say that due to the better class of machinery being installed in the newer mills, it is necessary that our drawings show the proper clearance and finish if we hope to maintain an interchangeability of parts.

F. C. SCHOEN: I would like to ask Mr. Gould about the factor he mentions for shafts and running fits—some factor times the cube root of the square of the diameter. What is that factor?

G. C. PFEFFER: I would like to ask Mr. Gould what you would do in the case of a badly worn shaft, turn the shaft down to a definite size or just turn it off enough to clean it up and fit a special size bearing to it?

W. J. REA: I have been pleased to listen to Mr. Gould's paper because he comes from another plant of our company. I am interested in seeing what they are doing. I can say that they are doing a lot more than we are. The standardizing of micrometers is very interesting to me. It has to be done with considerable care and discretion but the setting up of standards for shop use is not a particularly difficult problem.

I would suggest that on the standards board, that rough finish that is produced on one end of the standard has the appearance of a very artificially produced finish. I think that for the psychological effect in the shop we might well produce an actual shop rough finish on that end of the shaft so that the mechanic sees at once what is expected.

I think that there should be something done in the heavy machinery shops to arrive at a satisfactory solution to this problem of finish and allowance and length of fit, so that we get away from some of the problems of stalling in the press. That is always an embarrassing situation and causes a lot of loss and trouble. I think there should be something done to establish good standard practice on long fits. One thing very helpful is breaking the fits up where possible into short fits. This is often done by the draftsman, but some of the older drawings have very long fits, perticularly on large mill pinions and things of that nature where they are put on a spindle. It sometimes becomes very difficult to make allowances for a press fit in, say, a 30-in. diameter hole perhaps four or five feet long. I believe a good deal of study should be given to satisfactory shop practice for these long fits.

L. F. COFFIN: In connection with one point raised in the discussion, I wish to state that our engineering department was, of course, represented on the committee that prepared these Standards. They have cooperated to the fullest extent and though they realize it is quite a job, they are enthusiastic and perfectly willing to go ahead with some such means for making instructions to the machinist more explicit. This is a fine attempt on the part of Mr. Gould and his collaborators to improve maintenance work.

L. J. GOULD: We selected three factors for three classes of running fits—$.0009\sqrt[3]{D^2}$, $.0025\sqrt[3]{D^2}$ from the ASA and $.007\sqrt[3]{D^2}$ for coarser work. Other running fits are available, but these seemed sufficient to us. In the first two cases the tolerances are $.008\sqrt[3]{D}$ and on the clearance fit the tolerance is $\frac{1}{2}$ of $\frac{1}{64}$ in.

Mr. Rea's remarks about proper length of long fits bring out worrisome problems to which we cannot hope to find a standard solution. The necessary length of the fit and the use of keys are determined not only by the torque to be applied, but also by the thickness of hub and the necessity of assembling the parts by methods available in the plant. In general the press and shrink fit class 8 develops 30,000 lb. per sq. in. maximum in a steel hub and is therefore usually a limiting condition. There have been several studies of the problem of fits in the ASME. transactions. As you are all aware, many parts transmit torque without keys. The calculation of the required length of fits, class of fit and keys for large members is not simple. An engineer should furnish this information to the shop. Usually we use as tight a fit as possible, as large a key as we can, and sometimes weld as an afterthought. A great deal of money could be saved by rational studies of press fits.

The answer to Mr. Pfeffer's question about worn shafts lies in that part of our proposed standard called "adjusted fit". You will note that the tables are not based on particular sizes but on ranges. Thus the limits and fits are not listed as belonging only to a 5 in. shaft but to any size between $4\frac{3}{4}$ in. and 5 in. Thus while there are definite advantages in using a preferred number of sizes for which reamers and gauges are available, there is no necessity for holding to any particular size. We anticipate turning a worn shaft merely to clean and round up and making the mating part to suit.

Mr. Rea's comments on the rough finish samples are quite to the point. It does look artificial on the small shaft used but the same degree of roughness would not look out of order on a large shaft. We had funny results when we asked the tool room to make these samples. The rough finish turned out to be a practically perfect thread. It is a fact that too rough a finish is not economical.

Application of HEAT Transfer Data to FURNACE WALLS and ROOFS

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▲ ALTHOUGH many tests and heat transfer rates have been published, one is still completely bewildered when attempting to check resulting temperatures or heat loss tables published by numerous manufacturers. When an engineer desires to compare one type of composite wall construction with another, or to compare heat losses from various published sources, so much time and effort is required in the mechanics of checking that in the average case he gives up and, of necessity, accepts information supplied by the manufacturer or from closely comparable tables. Since conductivity constants of different insulation types vary over a wide range, comparisons should not be made where one manufacturer employs constants for one type of insulation and another uses constants for a different type.

When figuring heat losses through insulated walls or roofs, it must be remembered that the flow of heat through the refractory must equal the heat flow through the insulation and must also equal the heat emitted or dissipated from the outside surface by radiation and convection. In other words, with heat flowing through a series of resistances in this manner, the total flow, H, may be expressed:

H = H (through firebrick) = H (through insulation) = H (emitted to the air).

The rate of heat flow changes if the conductivity of the firebrick or of the insulation is changed. Likewise, a change in ambient air temperature or in velocity of the surrounding air will change the total heat flow. Much time and many tedious calculations are required to determine the heat flow rates resulting from a change in any one of these factors. Thus, heat loss figures submitted by various manufacturers on their designs can be compared only after calculations to determine the conductivities employed, and then recalculating each design using conductivities from the same curve. It is apparent, then, that some standardization of average conductivities would greatly simplify the problem of heat loss comparisons.

In order to facilitate such comparisons, the following data are presented in the hope that they will encourage further use of standardized average coefficient curves. The conductivity of standard first quality firebrick shows some variation, even when supposedly identical samples are studied in different leading laboratories. Some variation also exists in the conductivity of brick of different manufacturers and of different clays. Trinks, in his book on "Industrial Furnaces", suggests the use of an average curve to represent the average conductivity of first quality fire brick. This curve is reproduced in Figure 1, and there appears to be little justification for any modification of this curve, which can be applied to most commercial calculations without appreciable error.

The conductivity of insulating materials, however, varies over a considerably wider range. Trinks and Mawhinney both allow for the effect of cracks and the deterioration of the insulation in the figures they give for industrial furnace work, and the figures they give for conductivities of insulating brick should not be used as representative averages for block or plastic insulation. Also, many insulating materials will not stand the resulting high hot-face temperatures where insulation is applied to furnace walls, so that conductivities of these low temperature insulations should not be considered in an average conductivity curve. Even in the range where certain types of insulation are suitable for such service, there is considerable variance in the figures given by both manufacturers and testing laboratories. For comparative purposes, therefore, it is necessary to employ an average insulation conductivity curve which, like the average curve for fire brick, should be a representative average of numerous materials. Such an average is suggested in Figure 2. This average shows considerably higher conductivities than those claimed for certain insulations under laboratory test conditions. On the other hand, it is considerably lower than conductivities reported by Mawhinney as being representative of actual practice with attendant air leakage. It coincides approximately with averages previously used and lies about midway between the high and low figures reported.

Comparisons are altogether meaningless unless referred to identical conductivity figures. Even on this basis, and with standardized curves for firebrick and insulation, the various calculations are too tedious to check the average case.

The next step is the loss of heat from vertical plane surfaces which takes place by radiation from the wall surface and by convection currents to the surrounding air. Fortunately this loss is relatively uniform for the common materials making up the surface of the wall, so the same figures may be applied to either steel, masonry, or insulating material. Trinks' modification of the Stefan-Boltzmann law is widely used for figuring this loss and takes the following form:

$$HL = 0.155 \left[\left(\frac{T_o + 460}{100} \right)^4 - \left(\frac{T_a + 460}{100} \right)^4 \right] + 0.25 \, (T_o - T_a)^{5/4}$$

Where HL = Heat loss per sq. ft./hr. in Btu.
T_o = Temperature of outside surface.
T_a = Temperature of surrounding still air.

From this formula, curves shown in Figures 3 and 4 have been calculated using an outside still air temperature T_a of 60 degrees F. When the outside temperature of the wall T_o is known, the heat loss per sq. ft. per hr. can be read directly from these curves. This information in curve form is extremely valuable and a great time-saver, in heat transmission calculations. In this formula, the first part represents radiation and the second part, $0.25 \, (T_o - T_a)^{5/4}$, is the loss due to convection in still ambient air. Circulating air has a marked effect on this loss and if velocity is considered, the second part of the formula becomes:

$$0.25 \left(\frac{V + 68.9}{68.9} \right)^{1/2} (T_o - T_a)^{5/4}$$

where V equals the velocity of ambient air in feet per minute over the surface. This agrees with the formula as first stated for still air when V = O. Since it is almost impossible to determine correctly the actual velocity of moving air, and since heat transmission calculations have, at best, so many variables, for simplicity it is suggested that the factor of velocity be neglected for comparative purposes. This formula has been used successfully for years and variations should not be adopted until several authorities agree that the proposed modifications more closely represent true conditions. Its use as a standardized average is suggested.

Even with the use of these suggested standardized averages, making comparisons or checking a guaranteed figure of heat loss is still a long and tedious task. The consideration of a simple 9 in. firebrick wall with 2½ in. insulation, for example, will demonstrate the work involved. With an inside wall temperature of

FIGURE 1—Curve showing average thermal conductivity of firebrick with varying temperature (Trinks).

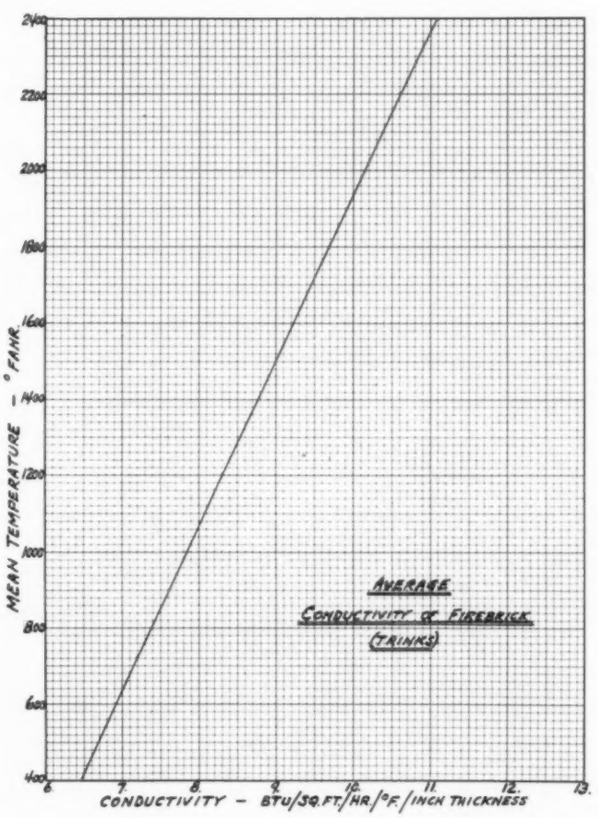
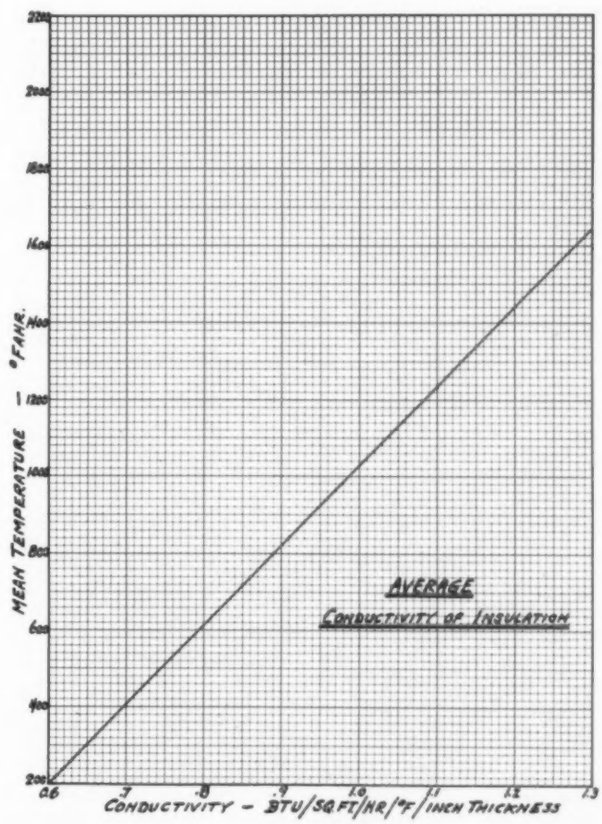


FIGURE 2—Average thermal conductivity of insulating materials with varying temperature.



2200 degrees F., find heat loss through wall; hot-face temperature of insulation; outside temperature with surrounding air at 60 degrees F. For simplicity we will call:

Heat loss ..... HL
Inside temperature ..... T
Interface temperature between firebrick and insulation ..... T_f
Outside temperature of insulation ..... T_o
Conductivity of firebrick ..... C_f
Conductivity of insulation ..... C_i

Since heat flow through the refractory, the insulation, and the heat emitted from the outside of the wall must be equal, the heat flow has this form:

$HL = C_f(T-T_f) = C_i(T_f-T_o)$ = Heat emitted at T_o.

Unknown quantities are T_f, T_o, and HL.

The probable temperature T_f must first be estimated and the heat transfer calculated, using values of conductivity applying to the estimated temperature range from Figure 1. Likewise T_o must be estimated and the proper value of conductivity C_i applied to the equation. If the quantities of heat calculated from each part of the equation do not come out equal to each other, a new set of calculations must be made with new assumed temperatures and conductivities corrected in the proper direction. As a first guess, take T_f = 1675 degrees F. From Figures 1, C_f for the range from 1675 degrees to 2200 degrees (average 1938 degrees) is 9.98 Btu. per sq. ft. per hr. per degree F. per inch thickness.

$$\text{Heat transmitted per sq. ft. per hr.} = \frac{9.98\ (2200-1675)}{9}$$

$$= 583 \text{ Btu.}$$

From Figure 3, for a heat loss of 583 Btu. per hr. the outside temperature T_o is 283 degrees F. Thus, the first and third parts of the equation are equal and if the second part comes out equal when substituting 283 degrees F. as T_o and applying proper conductivity C_i from Figure 2, the problem is solved.

Taking C_i as .976 for the range from 283 to 1675 degrees (average 979 degrees), the second part of the equation becomes:

$$\frac{.976\ (1675-283)}{2.5} = 543 \text{ Btu.}$$

Thus, the second part, 543 Btu., is too low which shows that the estimate of T_f was too low. Using the same procedure, it is necessary to try again and assume T_f = 1700 degrees and T_o = 278 degrees. Applying

FIGURE 3—Heat losses from rough vertical plane surfaces (50-400 degrees F.) in still air.

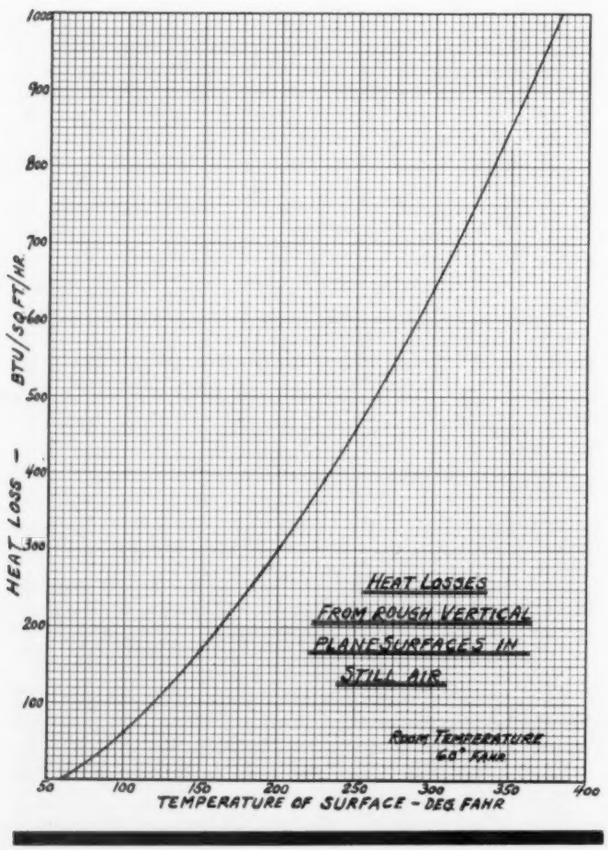
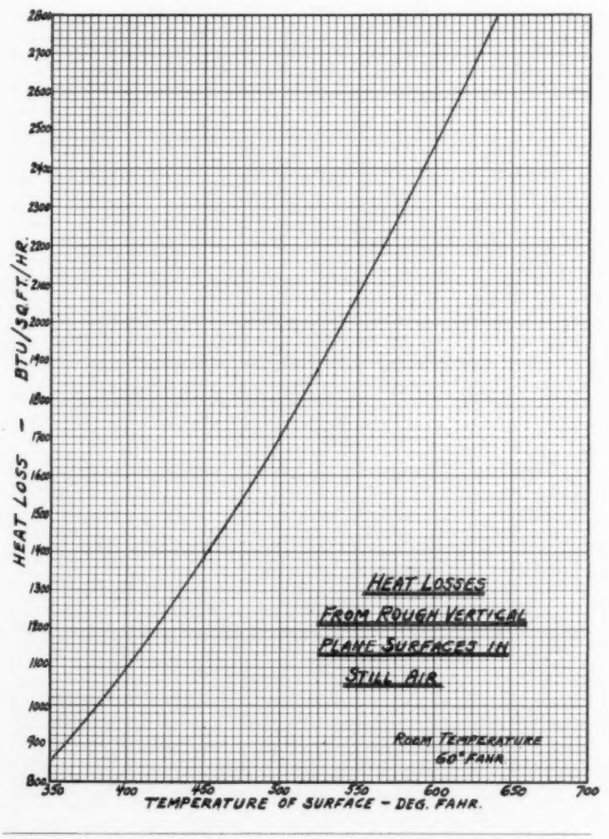

HEAT LOSS - BTU/SQ.FT./HR.
TEMPERATURE OF SURFACE - DEG. FAHR
HEAT LOSSES FROM ROUGH VERTICAL PLANE SURFACES IN STILL AIR
ROOM TEMPERATURE 60° FAHR

FIGURE 4—Heat losses from rough vertical plane surfaces (350-650 degrees F.) in still air.


HEAT LOSS - BTU/SQ.FT./HR.
TEMPERATURE OF SURFACE - DEG. FAHR.
HEAT LOSSES FROM ROUGH VERTICAL PLANE SURFACES IN STILL AIR
ROOM TEMPERATURE 60° FAHR

proper conductivities for the ranges involved, the three parts now become:

$$\frac{10.02\ (2200-1700)}{9} = 558 \text{ Btu.}$$

$$\frac{.98\ (1700-278)}{2.5} = 558 \text{ Btu.}$$

Heat emitted at 278 degrees (From Figure 3) = 558 Btu.

This time, the assumed temperatures were correct and the answers are:

HL..... = 558 Btu. per hr.
Hot face temperature of insulation = 1700 degrees F.
Outside temperature of wall..... = 278 degrees F.

The above solution was obtained after five sets of calculations, although only two are listed to save space. This illustrates the tedious work necessary to check one set of conditions. A change in conductivities of either the firebrick or the insulation will change the entire set of answers. For instance, if a conductivity of insulation is used which is 20 per cent lower than the average suggested by Figure 2, for the same conditions and by the same procedure followed in the foregoing examples, the following results are obtained:

	C_i	C_i less 20 per cent	Per cent change
Heat loss, Btu. per sq. ft. per hr.....	558	482	—13.67
T_f (interface temp. of insulation), degrees F.....	1700	1770	+ 4.12
T_o (outside temp. of insulation), degrees F.....	278	258	— 7.2

Raising the insulation conductivity 20 per cent shows the following:

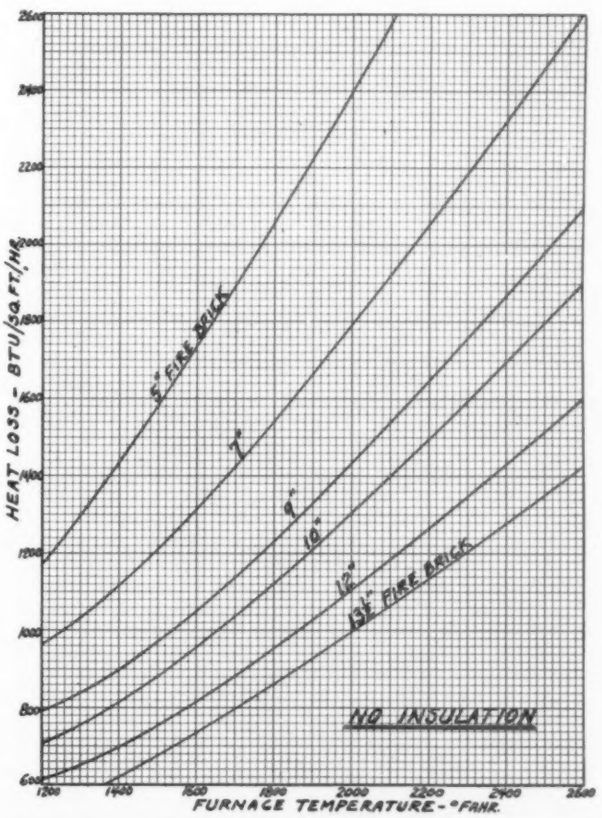
	C_i	C_i plus 20 per cent	Per cent change
Heat loss, Btu. per sq. ft. per hr.....	558	625	+11.5
T_f (interface temp. of insulation), degrees F.....	1700	1636	— 3.76
T_o (outside temp. of insulation), degrees F.....	278	296	+ 7.8

Likewise, the air surrounding the wall or arch may be at a higher temperature than the 60 degrees on which heat dissipation curves, Figures 3 and 4, were based. Here again, the entire set of answers is changed. Working out the same example on the basis of surrounding still air temperature at 100 degrees F. instead of 60 degrees F., we get these results:

	Air at 60 degrees F.	Air at 100 degrees F.	Per cent change
Heat loss, Btu. per sq. ft. per hr.....	558	552	—0.9
T_f (interface temp. of insulation) degrees F...	1700	1705	+0.3
T_o (outside temp. of insulation) degrees F...	278	300	+7.9

The above figures demonstrate that rather wide variations from the suggested standardized averages can be made without appreciably changing the results. The confusion and necessary time for calculations, where various conductivities, velocities, ambient air temperatures, factors bearing on equipment-location, etc., are specified, indicate a considerable advantage in referring to accepted averages. Unless such averages are employed, figures submitted have no basis of com-

FIGURE 5—Curves showing heat losses through uninsulated firebrick of varying thickness.



parison. Ordinarily, there is insufficient commercial interest involved to follow through such figures to a logical comparative basis.

By using the suggested average curves for conductivities, the data shown in Figures 5, 6, 7, and 8 were prepared Such data are really necessary to decide the type of construction to employ, the desirability of applying insulation, and the required thickness of refractory and insulation for a given specification. The curves assist an engineer to "think out loud" about such problems and to obtain reliable answers quickly.

APPLICATION OF HEAT CURVES

It is only by the use of the suspended arch that the contours and large sizes of roofs required by present day triple-fired heating furnaces have been made possible. Since the loss of heat from such large roof areas is a substantial percentage of the total heat required in the furnace for heating steel, much study has been given to the development of types that permit ready modification to give desired roof contours, and to keep heat losses down to a minimum. The most commonly used types of suspended arches employ extended heads or necks for support, or metal supporting castings, or some combination of metal and refractory neck supports. While ordinary iron castings suffice very well to support uninsulated roofs, the heat loss of uninsulated constructions causes poor furnace efficiency. The high first cost of the alloy castings to exist in the high interface temperatures encountered in insulated roof construction, has resulted in considerable design development and ingenuity in modern suspended roof constructions to avoid excessive first cost, and yet obtain the benefits of the fuel saving of insulated construction.

From the data on heat loss and temperatures, it is now possible to visualize more clearly what happens in a structure such as a flat suspended roof. Assume, for example, a type of construction as illustrated in Figure 9, which is made up of tile with 9 in. burning depth, insulated with 2½ in. of vermiculite and supporting heads insulated with 2 in. of vermiculite granules. This construction includes a straight section of 9 in. refractory plus 2½ in. insulation for a part of the cross-sectional area marked "AA". It also consists of a more complex section marked "BB", where part of the heat must flow through a greater thickness of refractory plus 2 in. of vermiculite granules, and part flows through the refractory to the channel supports, and then from the supporting channels, by emission, to the air. Moreover, due to application of the insulation in section AA, the heat flow and developed temperature at YY is dammed up, tending to force additional heat through

FIGURE 6—Curves showing relation of inside and outside temperatures of walls of various constructions.

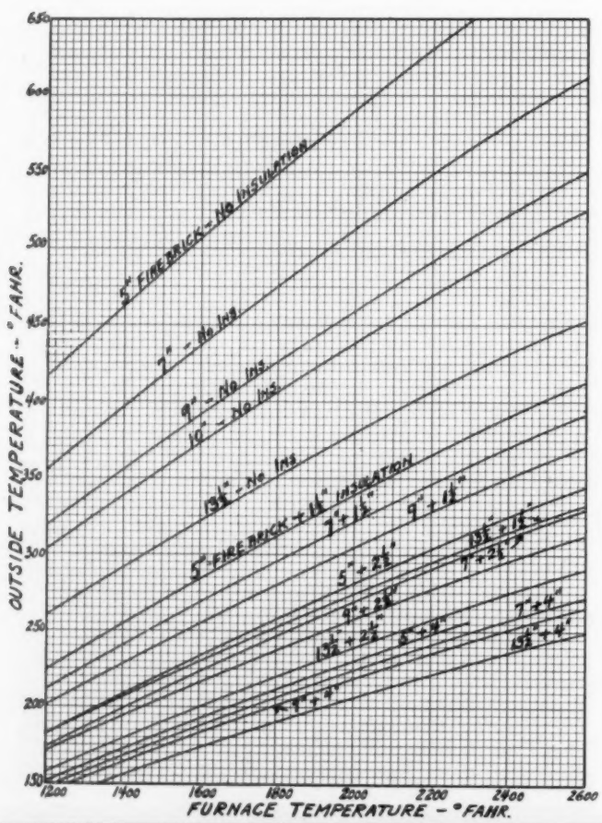
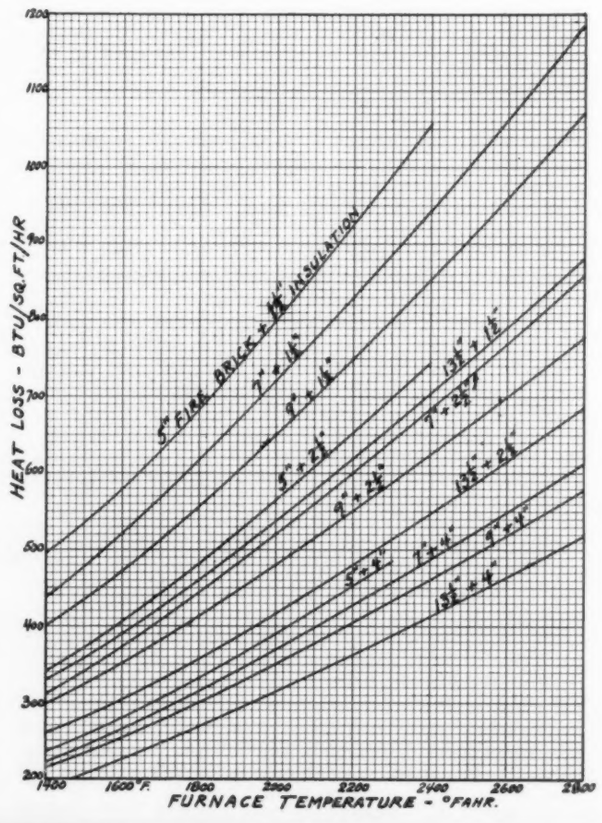


FIGURE 7—Heat losses through insulated firebrick walls of various constructions at varying furnace temperatures.



section BB. In determining the relative effect of developed temperatures and total heat flow of section AA on section BB, the system might be considered similar to the flow of water in pipes. Plane YY is the logical starting point, for at this point total flow of heat, H, through the 9 in. of firebrick is equal to the total flow through the insulated section AA plus the total flow through section BB. At an assumed furnace temperature of 2400 degrees F., the temperature against heat loss relationship for a section at YY will be studied.

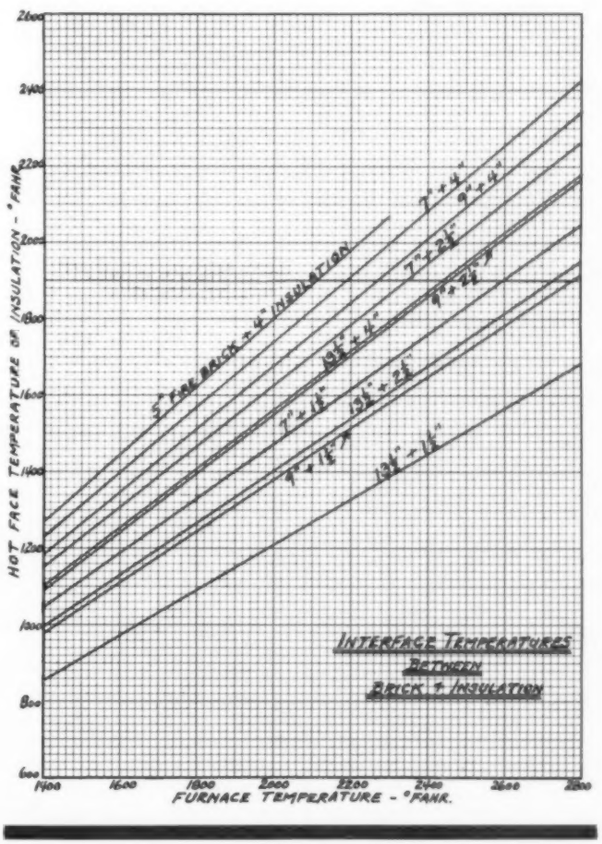
Considering first the 9 in. of firebrick, Figure 5 shows that for a 2400 degree F. furnace temperature, the heat loss is 1870 Btu. per sq. ft. per hr. for uninsulated firebrick. From Figure 6, this heat loss represents an outside temperature of 523 degrees F. With 2½ in. of insulation, the temperature of the outer face of the brick becomes 1860 degrees and the heat loss becomes 625 Btu. per hr. from Figures 7 and 8. Taking off similar points for varying thicknesses of insulation, Figure 10 is obtained. This curve might be termed a "heatomotive" curve, for no matter what the sum total of heat flows through insulation or heads may be, the total Btu. per sq. ft. per hr. must fall on this curve. Also, the total temperature drop through the firebrick and temperature existing at the outer face of the brick (plane YY) is definitely established to each total Btu. flow of heat. This is the same function for heat flow through firebrick as the conventional gpm. curve against pressure drop per foot of length for a water pipe. The theoretical limits of this "heatomotive" curve are as follows: one limit presumes an infinite thickness of insulation or an insulation of 100 per cent efficiency in which case the hot interface temperature would become 2400 degrees F., resulting in no heat flow. The other limit assumes maximum possible heat flow such as the case when the outside surface of the firebrick is covered by a cold brine cooled plate or other medium of infinite heat absorbing capacity. Only the part of the curve for the temperature range considered is shown. Regardless of the construction outside of the firebrick—whether insulated or bare—extended heads or supports of high conductivity metal—the total heat flow in Btu. per hr. per sq. ft. of roof and the equivalent temperature average at the outer face of the firebrick must fall on this curve. Having explained the development of the "heatomotive" curve, it can now be transferred to Figure 11 where it is designated as curve No. 1 and enlarged in the range to be studied for the heat loss and temperatures assumed.

It should be noted that Figure 11 assumes a constant furnace temperature of 2400 degrees but is plotted against "hot interface temperature" or temperature on the outside face of the firebrick, in order to make use of the variables common to the two sections of the construction. These common variables are the temperature and heat loss through the straight firebrick section existing at YY, the variation in heat loss through the insulated section AA for varying temperatures at YY, and the variation in heat loss through the heads BB for varying temperatures at YY.

Considering first the heat loss through the insulated section AA, this simply becomes the variation in heat loss resulting from differing inside temperatures, and is shown as curve No. 2, Figure 11. One point for this curve has already been determined from the point on the heatomotive curve for a 2400 degrees F. furnace; namely, interface temperature of 1860 degrees F., and heat loss of 625 Btu. In other words, for a temperature of 1860 degree F. at YY, the loss through the insulation is 625 Btu. In Figure 8, again using the curve for 9 in. firebrick and 2½ in. of insulation, it is noted that for a furnace temperature of 2000 degrees F., an interface temperature of 1550 degrees F. results. Then from Figure 7 for a 2000 degree F. furnace, a heat loss of 481 Btu. results. Hence, for a temperature at YY of 1550 degrees, a heat loss of 481 Btu. is obtained. Similarly, for a 1600 degree furnace the curves of Figures 7 and 8 show an interface temperature of 1240 degrees F., and a heat loss of 352 Btu. Similar points can be checked to obtain curve No. 2 of Figure 11. Curve No. 3 simply proportions curve No. 2 for the percentage of the total roof area made up of this construction.

The heat loss through the heads at BB can vary between two extreme limit. The minimum loss would be that resulting with the same insulation on the heads as employed at AA, assuming of course section AA having insulation with the lowest heat loss justified for the application. For the percentage of the total area made up of the heads, this minimum figure would be 130 Btu. or the difference between curve No. 2 and curve No. 3 at 1860 degrees F., and the total heat loss for the roof would be the intersection of curve No. 2 with the heato-

FIGURE 8—Curves showing inter-face temperatures between brick and insulation for various constructions and furnace temperatures.



motive curve No. 1, or a total heat loss of 625 Btu. per sq. ft. of roof. The maximum condition of heat loss would result if the heads were left uninsulated. Under this condition, it would make no difference whether the heat flows through the tile and is emitted to the surrounding air, or whether only a part of the heat goes through the tile, the balance going by radiation to the supporting channels, and then emitted from the surface of the channels to the air. The limiting quantity is the heat that can flow through the thickness of refractory in the heads, for the percentage of the roof area made up of this construction. This resolves itself simply into varying losses of heat through the uninsulated refractory for varying inside temperatures at YY. These losses can be read directly from the curve for 5 in. bare firebrick in Figure 5. This loss, shown as curve No. 4, Figure 11, for the percentage of area which is composed of heads, is 298 Btu. for 1400 degrees F. temperature at YY and 394 Btu. for 1700 degrees F. temperature at YY.

Curve No. 5, Figure 11 is the sum of the maximum possible flow through the neck of the heads when bare (curve No. 4), and the maximum possible flow through the insulated section (curve No. 3), both plotted against variation in temperature at YY. The point where this curve crosses the heatomotive curve No. 1 is the only point where equilibrium can exist, and gives that flow of heat through the 9 in. firebrick which will exactly equal the heat lost through the head area plus the heat lost through the area of the insulated section. The temperature indicated is the equivalent average that would permit this flow of heat. Thus, it is seen that the interface temperature, which would be 1860 degrees F. for the minimum possible flow condition, is depressed to 1670 degrees F. for the maximum possible heat flow of 804 Btu. per hr. per sq. ft. of roof.

The minimum heat flow given is essentially correct for the conductivities used. The maximum heat flow makes certain assumptions which cause a greater loss of heat than can actually result. With a greater flow of heat through the heads than through the insulated section, there must be some depression in temperature along YY due to flow through head section BB. For the insulated section AA alone, the temperature at the interface, for the 2400 degree F. furnace temperature used would be 1860 degrees F. Considering only the bare head section BB of the cross section area and thickness of the head, the outside temperature would be only 422 degrees F., and the temperature at b would be only 1150 degrees F. It is obvious, therefore, that there will be a flow of heat along YY from a to b so that some equivalent average will be set up at YY. While the graphical solution proposed shows this equivalent average to be 1670 degrees F., it is evident that there must exist some variation in temperature along YY. This is so because heat flowing along BB will travel along a line BbcB, while heat flowing at AA, a part of which will eventually drain out at BB, must follow a line AabcB, which is a considerably greater length of travel. Consequently, this indicates a greater flow than can be the case. Even on this basis, the range of error cannot exceed a maximum heat loss of 804 Btu. with the heads bare, and 625 Btu. with the entire construction insulated which, considering the complexity of the construction, is within reasonable limits.

FIGURE 9—Typical suspended arch with insulation applied, showing paths of heat flow.

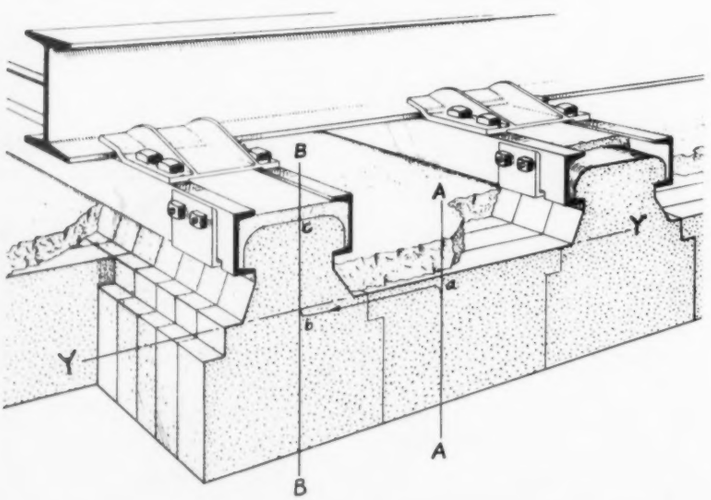
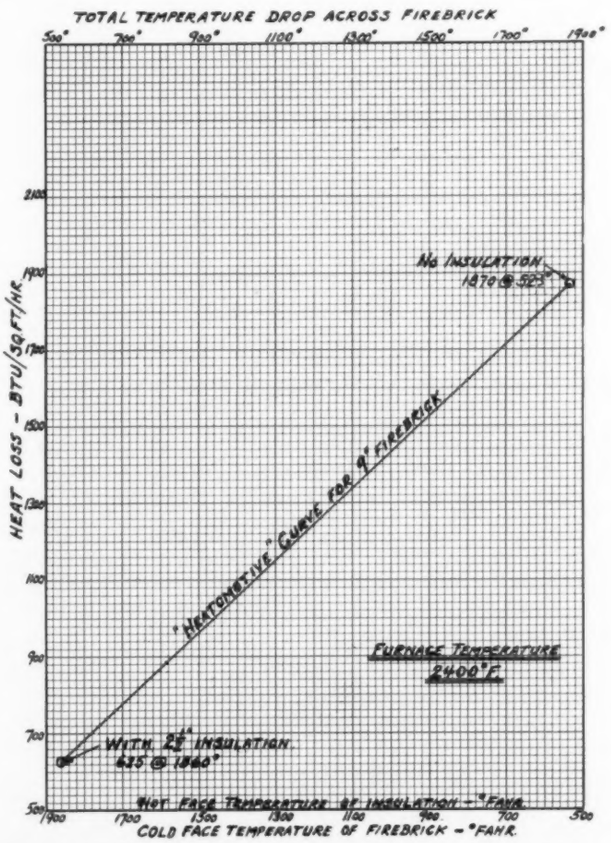


FIGURE 10—"Heatomotive" curve developed for 9 in. firebrick with 2400 degree F. furnace temperature.



Where, as is usual for this construction, insulation is packed around the heads themselves, another variable must be taken into consideration. The heat loss through the heads in this case is made up of the parallel flow of heat through (1) the insulated head tile section, and (2) the heat which will be radiated directly to the supporting channels, hence by conduction to the body of the channels, and emitted to the air from the body of the channels.

An analysis of the heat flow at this point indicates that the metal, which conducts heat many times as rapidly as the firebrick, will quickly conduct to the entire emitting surface of the supporting channels any heat received from the firebrick, where exposed to the channel. The amount of heat so picked up will depend, therefore, on the contact area of the firebrick with the supporting channels, which is only 12 per cent of the heat emitting area of the firebrick heads. Assuming heat will flow along the lines of least resistance, it has been assumed that as much as 50 per cent of the total heat flow which can come through the restricted neck area might flow by radiation and conduction to the metal supporting channels. This is greater than the true maximum possible, as 12 per cent of the heat emitting area cannot account for 50 per cent of the total flow through the restricted neck area without exceeding the principles of heatomotive flow rates.

On the basis of this assumption, heat losses for insulated 5 in. tile are taken from Figure 7, and for the same tile without insulation from Figure 5. Then, for each temperature at YY, one half of each loss is taken, and the sum of these losses is then proportioned for the percentage of the total roof area made up of this construction, and the results plotted as curve No. 4A. Curve No. 5A, which is the sum of curve No. 3, for the insulated portion, plus curve No. 4A for the insulated heads, represents the total heat flow for the entire roof area, plotted against varying temperature at the interface YY. In the same manner as the example given for uninsulated heads, the crossing of curve No. 5A with the heatomotive curve No. 1 represents the total heat loss of 715 Btu. per sq. ft. per hr. with insulated heads, and an equivalent interface temperature at YY of 1765 degrees F.

It will again be noted under possibility of errors in calculation that in this case, assumptions have now limited errors from a minimum loss of 625 Btu., for a fully insulated roof, to a maximum possible loss of 715 Btu. assuming very generous losses due to cross flow of heat to the supporting channels, which is a very limited

FIGURE 11—Graphical solution for heat loss through the suspended arch shown in Figure 9.

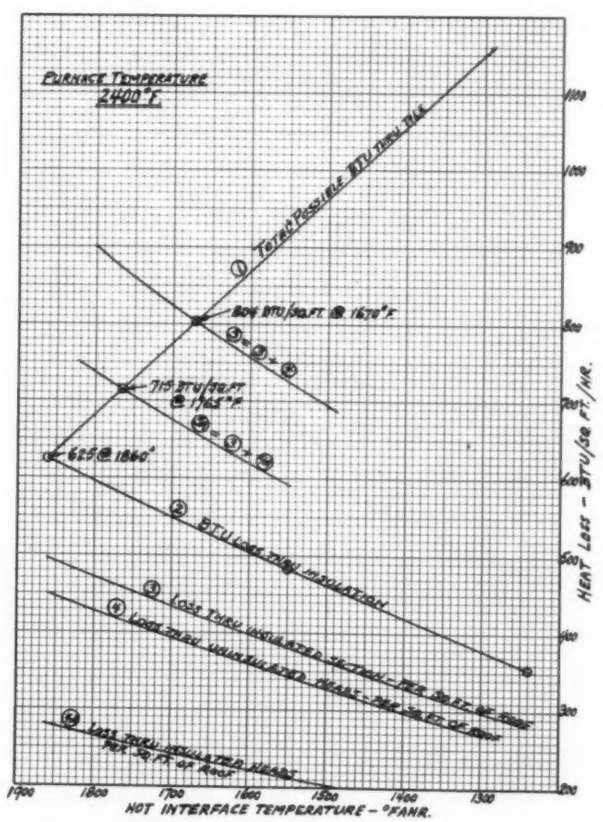
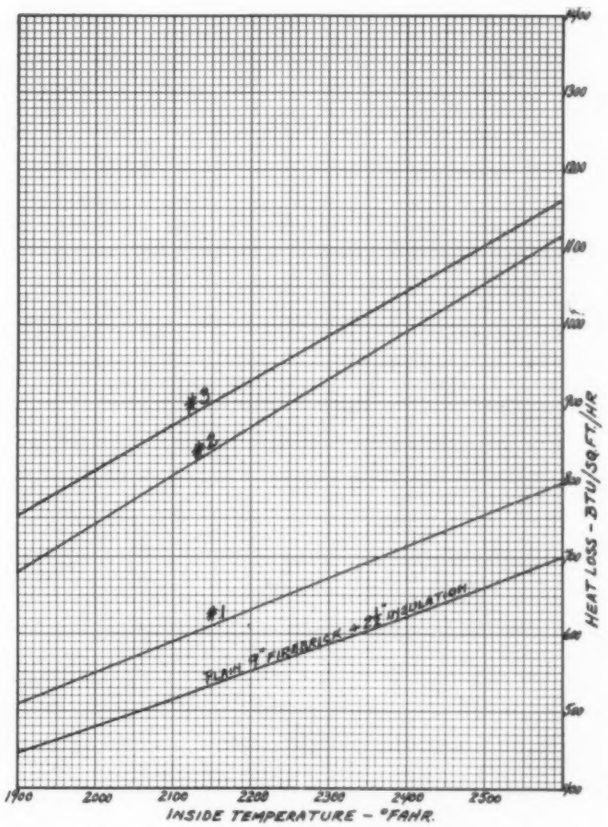


FIGURE 12—Curves showing heat losses through various types of arches, determined by the graphical method.



percentage of error. The assumption of 50 per cent heat to the channels may show 30 to 40 Btu. greater heat loss than can actually exist, but this becomes a negligible percentage of the loss for the total roof section.

The two preceding examples show the work necessary to evaluate the heat loss for a typical design of roof at only one furnace temperature—even with the mass of data given in Figures 1 to 8 available. The same calculations were repeated for other furnace temperatures and the results plotted in curve No. 1 of Figure 12. Curves No. 2 and No. 3 show results of applying the same analysis to roofs of other constructions. Some modification is required where refractory heads are replaced in whole or in part by cast metal supports. Reliable data for the specific conditions involved very meager and the calculations for differing cross sectional areas of supports of different designs become involved. For a conservative assumption, an example in Trinks' book on "Industrial Furnaces" analyzing heat loss through metal projecting out of a furnace was employed to determine the heat loss through metal supports. This example does not set up the maximum possible heat loss but can be employed with reasonable accuracy for ordinary work.

All of the heat loss calculations for roofs have neglected the fact that heat losses for horizontal surfaces facing upwards exceed losses from vertical surfaces by 15-30 per cent. For roof heat losses, at least 20 per cent should be added to all figures given whether supported or sprung arch construction is considered. However, in figuring the saving in fuel resulting from insulation, or in modification of construction of the roof itself, it must be borne in mind that only a part of the heat supplied in the fuel is available for heating steel. The balance is lost in door, radiation, and in flue gas losses. Therefore, in many reheating furnaces the fuel saving will be twice the actual Btu. saving through the roof depending upon exit gas temperatures. This fact is illustrated in detail for varying fuels and types of furnaces in books on the subject, and will not be covered here.

It should also be borne in mind that application of insulation sometimes results in shortened refractory life and increased repairs. Tonnage and minimum repairs are the primary considerations of the operating man. These must be assured. Super-duty refractories and temperature control may be necessary to prevent overheating which can develop very rapidly with insulated constructions. For comprehensive overall results, it thus may be necessary to justify as component parts of low heat loss operation the cost of super-duty refractories, furnace temperature control, and insulation.

CONCLUSION

It is practically impossible to advance test data which will apply unconditionally to all of the variables existing where heat is involved. Different makes of refractories, insulation, air space, metal thickness, proximity to hot or cold surfaces, type of emitting surface, and local constructional details introduce artificial conditions which make application of any one specific test unreliable for universal use. It should be borne in mind that all of the data submitted in Figures 1 to 8 represent a digest of the best test information availzble. If it can be shown that the average conductivities and heat emission data suggested in Figures 1 and 4 do not represent fair averages of actual test results, these curves should be modified to represent such averages.

The essential point is that curves of the type presented in Figures 5 to 8 cannot be developed without the use of data from Figures 1 to 4. Therefore, Figures 5 to 8 are, in effect, a form of multiplication table based on the average of the results of actual tests. With such a multiplication table available, it is possible to compare or modify proposed constructions in minimum time, with minimum effort, and yet with assurance. The graphic solutions illustrate how the multiplication tables can be used in the solution of actual problems.

As stated by Fred A. Harvey in concluding his paper before the American Ceramic Society in Buffalo, "The increased use of insulation necessitates more accurate control of furnace operation and increased understanding of the refractories used. It is hoped that this study will contribute its small part to the total needed knowledge". A usable set of "multiplication tables" to enable better and quicker visualization of temperature and heat flow is another small part in this "total needed knowledge".

SULLIVAN DISCUSSION

(*Continued from page 47*)

for the electrical engineers to be on the ground very early,—before the dimensions of the proposed motor room are definitely fixed; in other words, they should, figuratively speaking, put their foot in the door so as not to find themselves later on with too little room to properly install the electrical equipment. The need of doing so, for the ultimate benefit of the steel mill plant, is quite obvious.

I believe, at the same time, that it is equally important for the electrical engineer not to take for his equipment any more space than strictly necessary. I know of a few motor rooms where the amount of electrical equipment could be easily doubled—with enough space left over for a good-sized dance hall. Such a layout is almost as bad as the one where the electrical equipment is crowded, poorly housed, and inaccessible. It is right here where a good electrical engineer should step in, protect the interests of his department, as well as the interests of his whole plant.

I remember clearly one instance when a hot strip mill motor room was being laid out. For several days the electrical equipment, represented by templets, had been painstakingly moved back and forth on the general plan; some electrical apparatus had to be redesigned to suit the available space; and, finally the motor room dimensions were cut down sufficiently to save $40,000—$50,000 in building cost as compared with the tentative plans made before the electrical men were on the job. Granted that this might have been an exceptional case. But, similar opportunities, possibly on a smaller scale, are always present. Here is the economic basis for having the electrical engineers early on the job—before the building dimensions are finally set.

NEW MEMBERS

Active

Laurence S. Dahl,
Assistant General Superintendent,
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Irvin Works, Dravosburg, Penna.

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Ecorse, Michigan.

D. Haig Leckie,
Engineering Department,
Steel Company of Canada, Ltd.
Hamilton Works,
Ontario, Canada.

George F. Whitehead,
Wire Mill Foreman,
Copperweld Steel Company,
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Frank A. Johantges,
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International Harvester Company,
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A. H. Davis,
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Frank H. Koss,
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93" Cold Strip Department,
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Hubert Caldwell Smith,
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Napuria Works, Burnpur, India.

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International Harvester Company,
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Hot Strip and Bar Mill,
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Detroit, Michigan.

Arch R. Smith,
Sales Manager,
The Ready-Power Company,
Detroit, Michigan.

Frank W. Robertson,
Sales Manager,
Edward W. Voss,
Pittsburgh, Penna.

DISTRICT CHAIRMEN

W. J. Wilson

BIRMINGHAM DISTRICT SECTION

W. J. Wilson attended Birmingham, Alabama, public and private schools, business college, completed a correspondence course, and special vocational studies at the University of Alabama. Mr. Wilson began his electrical career in 1904 with the Schuler Brothers wire mill. In the same year he went with the mining division of the Tennessee Coal, Iron and Railroad Company, where he remained for about a year, returning to the Schuler Brothers wire mill. From there he went to Dimick Pipe Works. His next position was with the Southern Iron and Steel Company in Gadsden for a period of 2½ years. In 1911 he left Gadsden to go with the American Cast Iron Pipe Company as chief electrician, from which he advanced to electrical superintendent, his present position.

Arthur R. Dibben

CHICAGO DISTRICT SECTION

Arthur R. Dibben began his electrical career as an electrical apprentice at Illinois Steel Company's South Works, Chicago, Illinois, in 1904. From 1909 until 1920 Mr. Dibben was employed by various steel plants and plants allied with the steel industry in and around the Chicago district. In 1920, he entered the employ of the Mark Manufacturing Company at Indiana Harbor, Indiana. This plant was later taken over by the Steel and Tube Company of America, and in turn was later absorbed by the Youngstown Sheet and Tube Company, where Mr. Dibben has continued in his work as assistant electrical superintendent. He studied electricity in the Chicago public evening schools.

Isaac N. Tull

CLEVELAND DISTRICT SECTION

Isaac N. (Ike) Tull, was born in Anniston, Alabama, raised in North Carolina, attending public schools in Kinston, and State College at Raleigh, graduating with a B. E. degree in electrical engineering in 1910. For two years, between public school and college, he was employed by Carolina Telephone and Telegraph Company as installer, lineman and general trouble-man. For a short time after leaving college, he was employed by Southern Bell Telephone Company as a central office man at Columbia, South Carolina, leaving there to enter General Electric Company's test course at Schenectady. He was transferred to their Cleveland office's engineering department in 1912, remaining there until 1915, when he was employed by Corrigan, McKinney and Company as electrical engineer.

At that time, Corrigan, McKinney and Company operated through various operating companies only blast furnaces and metal mines, but had started to build additional blast furnaces and a steel plant at

W. J. WILSON

ARTHUR R. DIBBEN

I. N. TULL

Cleveland, to be followed by extensive electrification of the iron mines, and the opening of coal mines. The ensuing twelve years were spent in engineering and construction work, and in 1927, general supervision of electrical maintenance and operations was added to those duties. After the merger with Republic Steel Corporation in 1935, Mr. Tull became electrical superintendent of the Cleveland District for Republic.

L. R. Milburn

DETROIT DISTRICT SECTION

L. R. Milburn, electrical engineer, Great Lakes Steel Corporation, Ecorse, Michigan, was graduated from the University of Michigan with a degree of electrical engineering in June 1918. From July 1918 until December 1918, Mr. Milburn was in the United States Army. In January 1919 he went with the General Electric Company doing testing, complaint, installation, and apparatus sales work. In March 1925, he moved to the Louisville Gas and Electric Company where he did construction work until October 1929, obtaining excellent knowledge of the working of a central station industry. Starting his steel mill career in October 1929 with the Great Lakes Steel Corporation as electrical draftsman, Mr. Milburn remained in this position until 1933 when he was appointed acting electrical engineer. In 1935 he was promoted to electrical engineer.

George C. Pfeffer

PHILADELPHIA DISTRICT SECTION

George C. Pfeffer entered the employ of R. D. Wood Company at the Camden Iron Works in 1907 as electrician. Mr. Pfeffer transferred to the Florence Pipe Foundry and Machine Company, Florence, New Jersey, in 1911 as assistant to the chief electrician. In 1914 he was advanced to the position of chief electrician, and in 1936 was placed in charge of all power in addition to electric power.

Freeman H. Dyke

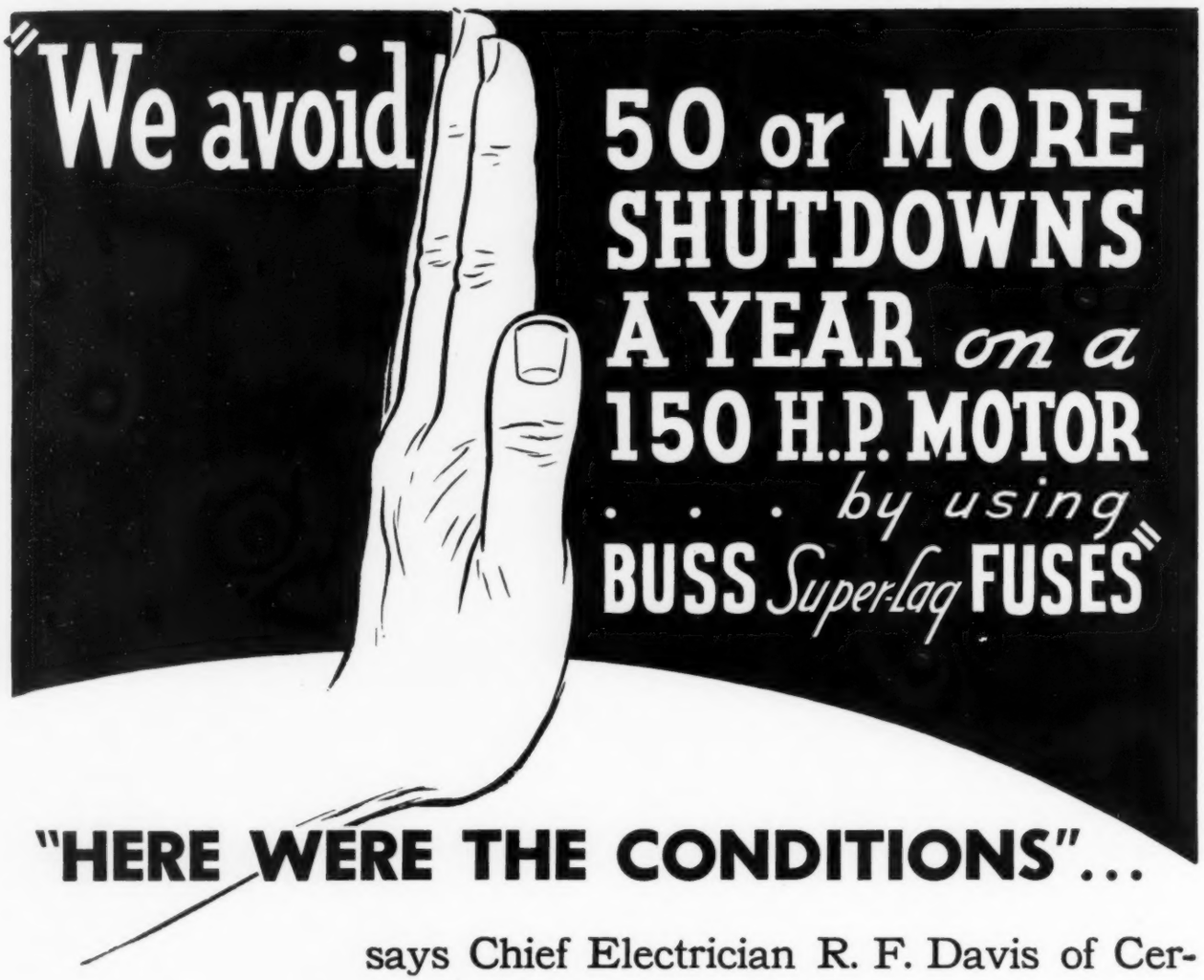
PITTSBURGH DISTRICT SECTION

Freeman H. Dyke graduated from Phillip Andover Academy and from the Massachusetts Instutute of Technology. Mr. Dyke started in the steel business with the Wheeling Steel Corporation at their Portsmouth plant in 1920, and with the exception of three years with the Jones and Laughlin Steel Corporation he has been with Wheeling Steel Corporation continuously. After serving in several capacities in various departments, Mr. Dyke became superintendent of the blooming, bar and hot strip mills at the Steubenville plant.

L. R. MILBURN

GEORGE C. PFEFFER

FREEMAN H. DYKE



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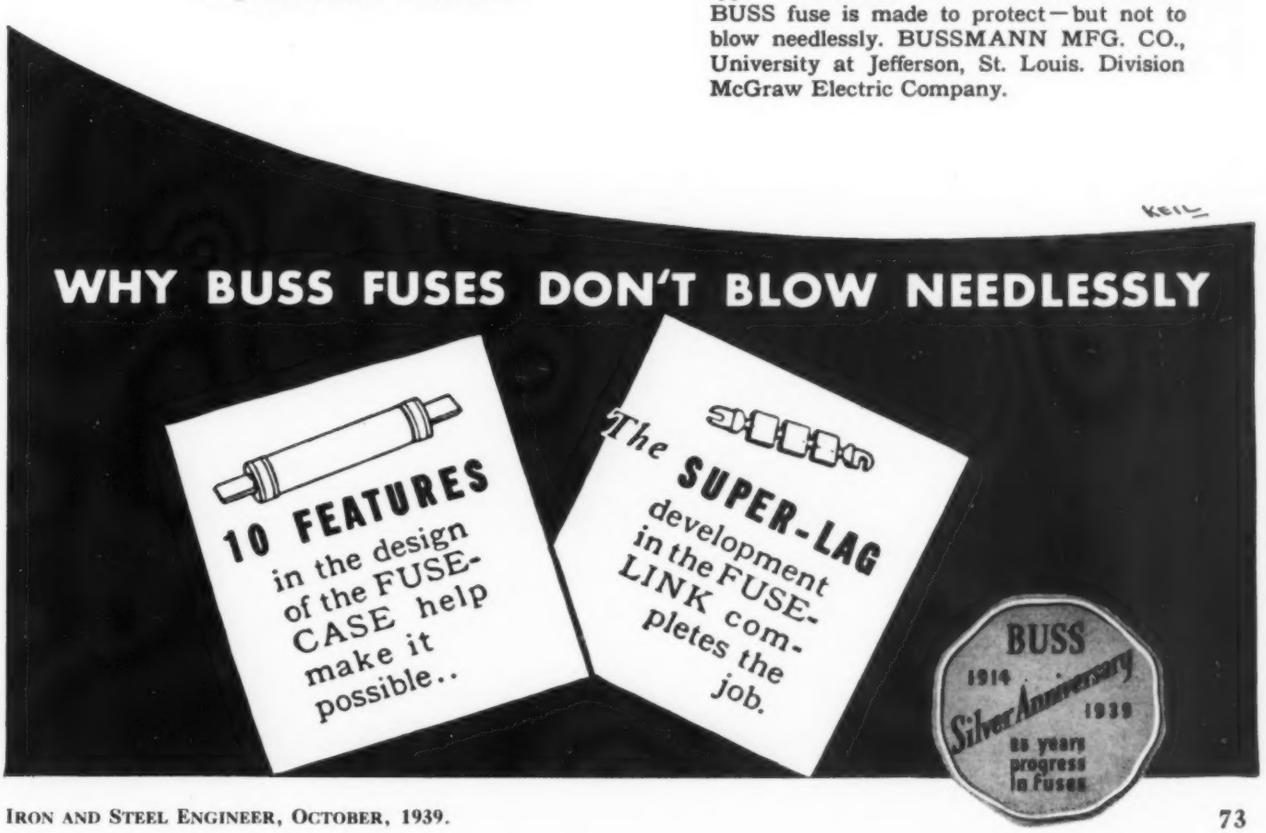
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1939
25 years progress in fuses

STATEMENT OF POLICY

The world is entering a crisis, the result of which no one can foresee. Other wars have brought inflation, followed by unemployment and depression after peace was achieved. America's experience in the World War illustrates this fact.

Much of this post-war trouble would have been eliminated by a more foresighted price policy on the part of manufacturers and distributors. Price inflation by the seller when he had a dominant position resulted inevitably in reaction with deflation, depression and suffering. Many of those price increases were not warranted.

Before such an inflationary cycle of prices is again started, we publicly pledge ourselves, as far as possible, to maintain present prices.

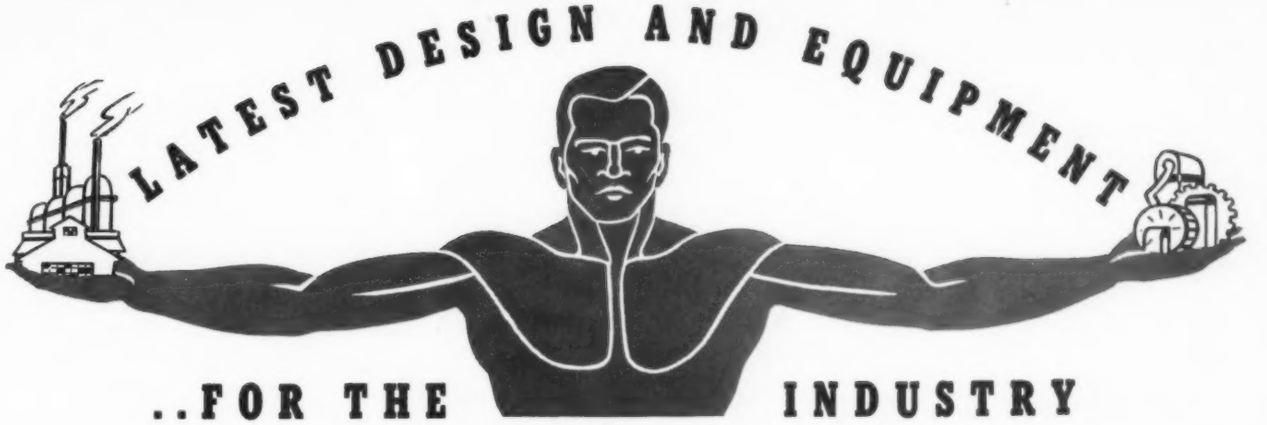
Further, if the materials we buy are increased in price, or the cost of labor is increased, then we pledge ourselves to raise selling prices no more than the bare increase in cost of raw materials and labor going into our products.

Further, we pledge ourselves to pass on to our customers the reduction in cost made possible by better manufacturing methods, wider distribution and technical advances in production.

THE LINCOLN ELECTRIC COMPANY

Cleveland, Ohio
October 2, 1939

J. F. Lincoln
President



ALL-WELDED OPEN HEARTH LADLES FOR T. C. I.

▲ Tennessee Coal, Iron and Railroad Company has received its first two all-welded open hearth ladles for service at its Ensley Works. Each of these two ladles, which were built by the Blaw-Knox Company, has a capacity of approximately 140 net tons, and weighs 39,250 lb. without the lining. The dimensions are as follows:

Top, major axis, inside..11 ft., 3¾ in.
Top, minor axis, inside..10 ft., 5 in.
Bottom, major axis, inside.....10 ft., 0¼ in.
Bottom, minor axis, inside..... 9 ft., 2¼ in.
Depth, inside.....11 ft., 2¼ in.
Trunnion center to center.....12 ft., 4 in.

With respect to distinctive design features, the ladle is truly all-welded, including the trunnion construction and reinforcement members. The trunnions proper are solid forgings of 12 in. diameter with a shank on each about 16½ in. square. This shank extends through the ladle shell, to which it is fully welded. On the outside of the shell, a system of vertical and horizontal ribs is welded to the trunnion shank as well as to the face of the shell.

A further point in the design is the attachment between these ribs forming the trunnion pads and the heavy stabilizing rings that girdle the ladle. In this case, the top ring is 4½ in. thick and extends out from the ladle shell about 6½ in.; the lower girdle has the same thickness but its width, because of the taper in the shell, is about 9 in.

This form of construction, following a fundamental theory of design, definitely ties together the shell, the trunnions, and the stabilizing rings, which all act together to carry the load. There is no reliance on the rings themselves to resist the torsional moment, as was assumed in an older theory, since the shell plate and reinforcement members—being welded together—act as one unit. This is considered to benefit the life of the lining. There is also a design advantage in that the proportional strength of the shell plate is taken into account, enabling lighter construction with consequent increase in crane pay-loads.

Among other features of the design is the use of a uniform thickness of plate throughout the shell. The bottom of the ladle is butt-welded to the shell and has a dish form rather than the flat shape common to some of the older type ladle bottoms. Long service usually deflects a flat bottom to at least a semi-dish, and it is almost impossible without excessive reinforcement to prevent this occurrence. Consequently, it is thought to be an advantage to initiate the dish design. The elimination of abrupt changes of section reduces the possibility of severe localized stresses. Both this accomplishment and the form of the ladle bottom are also considered to benefit the life of the lining, and of the ladle as a whole.

Modern welded ladle design renders strength and durability with lighter construction.

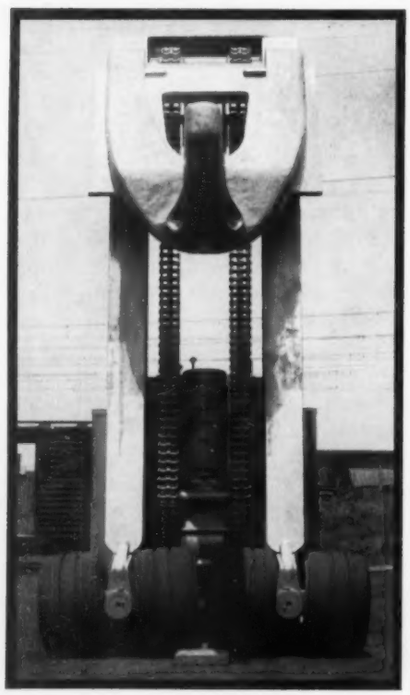
NEW TRACTOR AIDS PLANT OPERATIONS

▲ Consistent with the progress of the steel industry, a big lifting tractor has been developed by the Yale and Towne Manufacturing Company capable of handling loads up to 25,000 lb. Because it has to fit into the continuous operation of the modern mill, the tractor must be on constant call. It must perform smoothly, swiftly and safely. Time out of service would interrupt the rigid production schedules. To reduce this possibility to a minimum, and to insure coordination with modern steel mill equipment operating and construction features have been incorporated as follows: unit electric welded steel frame with longitudinal steel girders 1½ in. thick; heavy H-beam upright members; alloy steel parts throughout; 71-in. overall tread of rubber at load end; and independent articulation of dual load wheels for operation over rough ground.

The steering is effected electrically and is of the follow-through type. Complete articulation is obtained by having the drive unit mounted in a massive fifth wheel, supported by large roller bearing for easy steering. An overall height of 148 in. provides a ram height of 15 in. in low position and 100 in. in maximum raised position. The lifting ram is 51 in. long, while the overall length of chassis exclusive of load is 141 in.

The battery compartment is of ample size to accommodate a wide range of types and capacities of batteries or gas electric units.

With a capacity of 25,000 lb., this tractor fits into the continuous operation of the modern mill.



J. & L. DEVELOPS CARBANALYZER

▲ Jones and Laughlin Steel Corporation has made available to the entire steel industry a new, inexpensive instrument for making accurate and rapid carbon determinations of the bath in open hearth furnaces. This was developed by the research and development division of the general metallurgical department.

This instrument, the carbanalyzer, is substantially comparable in accuracy with chemical analysis, and in speed with the traditional fracture test. It is designed to be used under mill conditions and to give continued, trouble-free service. Being a rugged, portable instrument which is completely self-contained, it may be set up and used in any convenient location. Temperature changes or normal mill vibration do not affect the accuracy of the results. It is calibrated by checking the instrument readings against carbon determinations by chemical analysis and since the resulting curve is reasonably smooth, a relatively small number of these comparisons are sufficient. Readings are taken in a few seconds and the complete operation, including the preparation of the sample requires only three to five minutes.

After extensive tests of the new instrument on baths in the small experimental open hearth furnace in the pilot plant laboratory, additional units were built and placed in all the company's open hearth shops. These instruments have been used in the works for nearly a year and have given the satisfactory results which the laboratory tests predicted. Their use has proved to be an important factor in quality control.

RECTIFIER UNIT TO BE INSTALLED

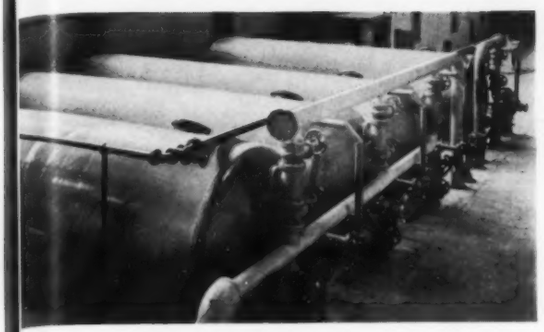
▲ Carnegie-Illinois Steel Corporation has installed an ignitron rectifier in the Edgar Thomson Works at Braddock, Pennsylvania. This 1000-kw., 250-volt unit will tie into the plant bus and furnish power for miscellaneous direct-current equipment.

The ignitron rectifier and associated apparatus, manufactured by the Westinghouse Electric and Manufacturing Company, is designed to operate from a three-phase, 6600-volt power-supply system. The unit will consist of two assemblies of six ignitron tubes, each being complete with equipment for maintaining and indicating vacuum. The unit will be rated 1000 kw. at 250-volt direct current continuously with overload capacity of 125 per cent for two hours and 200 per cent for one minute. The rectifier unit will be completely automatic. The high efficiency, ease of installation, and compactness of the ignitron rectifier makes it a very desirable source of direct-current power in a steel plant. It is expected that this rectifier will be installed before January, 1940.

FILTERS FOR DESCALING SYSTEM

▲ In the hydraulic descaling systems as applied to modern strip mills, complete removal of abrasive solids is a prime necessity if excessive wear and nozzle stoppage are to be avoided. Successful descaling, upon which strip quality depends to a considerable extent, demands that the small orifices in the spray nozzles remain open and of constant area. In the new tin mill plant at the Indiana Harbor Works of the Youngstown Sheet and Tube Company, this requirement was fulfilled by the installation of a bank of four Cochrane pressure filters, each 8 ft. in diameter and 30 ft. long, through which passes the water drawn from Lake Michigan.

The water then flows to a storage tank from which the 1300-lb. hydraulic descaling system is supplied. After descaling, the water is reclaimed by a settling and straining process and re-



Pressure filters effectively remove abrasive solids from water for descaling system.

used at low pressure for cooling mill rolls.

Results obtained show a complete removal of the undesirable solids, thereby preventing damage to the pumping machinery, and reducing wear on the orifices in the spray nozzles, resulting in consistently good descaling, reduced maintenance, and a lower consumption of water for this purpose.

PRESSURE SYSTEM FOR LUBRICATION

▲ The need for compact, economical and efficient full pressure feed lubrication systems has been recognized for some time. As the result of considerable research and field experience, the De Laval Separator Company presents a complete new line of assembled unit pressure lubrication systems, known as the "Unilube" systems, in sizes and types to meet varied lubrication requirements. These systems are compact and integral, furnishing lubricantin streamline pressure supply to bearings or gear meshing points. They incorporate in a single unit automatic full feed pressure filtration and automatic temperature and pressure control of the lubricant supply.

This lubrication system is especially adapted to industrial plants, such as steel mills, utilizing reduction gear drives, large motors and motor-generator sets, roll neck bearings, and other machinery for which force feed, pressure lubrication is desirable.

EFFECTIVE SEAL FOR BEARINGS

▲ Designed to give positive sealing of bearings and thus eliminate oil leakage and oil contamination, the Hurtt Air Seal can easily be applied to any new bearing and to a great percentage of existing roll neck bearings, including anti-friction bearings. In principle, the air seal can be best compared to the caissons used in tunneling under rivers, where air pressure is maintained somewhat higher than the outside pressure. In applying this principle to a bearing seal, low pressure air (½ to 1 lb. per sq. in.) from blower or from the common air supply is introduced between two seals, one facing the lubricant supply and the other facing the coolant supply. Thus, a barrier of air effectually opposes entry of any contaminating agent or exit of the lubricant. A

Two Cleveland all-welded magnet cranes in a modern mill. 10 ton, 100'-0" span crane in foreground. Other crane is 15 ton.

In mills where various cranes are used and where their merits can really be compared Cleveland *all-welded* cranes are rated high.

They retain that solid, rigid feeling inherent with welded cranes even after years of hard service because in the all-welded construction there is nothing to loosen.

Because welded parts cannot sag or shift, misalignment does not occur, maintenance is usually cut to a fraction of that required for ordinary cranes.

THE CLEVELAND CRANE & ENGINEERING CO.
Wickliffe, Ohio

CLEVELAND CRANES

ALL-WELDED OVERHEAD TRAVELING CRANES

Other products: CLEVELAND TRAMRAIL and STEELWELD MACHINERY

Is your wiring WELL DONE?

Take a good look at a simmering strip of bacon and you'll see an accelerated demonstration of one of the major causes of wire failure. Notice how quickly it loses its rubbery flexibility, shrinks, crinkles and even becomes crisp, dry and brittle if you give it too much heat . . . and remember that *the same thing happens to heat-exposed wiring* if it isn't insulated with heat-resistant asbestos as Rockbestos is.

Organic insulation may not curl up under a heat blasting as quickly as a strip of bacon, but it goes through exactly the same process. Drying out, it gradually loses flexibility and becomes so brittle that it cracks, opening paths for moisture and current - leakage. Then comes trouble, equipment outage and an expensive replacement job which might have been avoided if Rockbestos asbestos insulated heat-resistant wire had been used.

If you want to see your electrical maintenance expense take a satisfying drop use Rockbestos, the wire with Ten Tested Values, for heat-exposed, control, power and lighting circuits or heat generating equipment. It is heatproof, fireproof and resistant to oil, grease or corrosive fumes.

TEN TESTED ROCKBESTOS VALUES

1. Heatproof
2. Fireproof
3. Permanent
4. Lower maintenance cost
5. Resists heat and vibration
6. Saves work
7. Oil and Greaseproof
8. High overload capacity
9. Permanently flexible
10. Greater carrying capacity

Our No. 10-E catalog describes many of our standard constructions and illustrates several typical applications. We'll be glad to send it and free samples, too. Rockbestos Products Corporation, 936 Nicoll St., New Haven, Conn.

Also refer to Electrical World Buyer's Reference

badly worn or damaged seal may still function satisfactorily, and is indicated only by an increased air flow to the seal.

The air seal is positive, simple and dependable, and by preventing leakage and contamination, will save lubricant as well as materially reduce the first cost of any lubricating system. Further information may be obtained from W. T. Hurtt, 871 Graham Boulevard, Wilkinsburg, Pennsylvania.

SOCIETY AWARDS

SAFETY TROPHY

▲ For outstanding achievement in the advancement of safety during the past year, Mackintosh-Hemphill Company has been awarded the President's Trophy of the Pennsylvania Manufacturers' Association. This is the first time that the award was made to any company since 1935.

The company's Midland, Pennsylvania, plant has operated almost at capacity from June 27, 1938 to date without a disabling accident. The mill has two previous no-accident records. The first included 466 days from March 22, 1932 to July 22, 1933, and another of 505 days from January 18, 1934 to November 5, 1935.

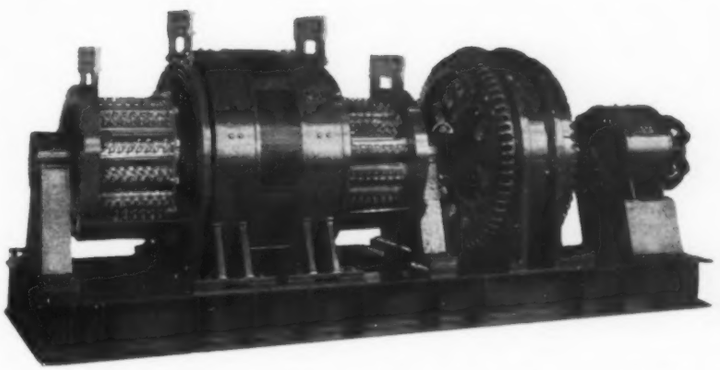
NEW ELECTRODE

FOR SMOOTH WELDS

▲ A new arc welding electrode, which will facilitate finishing operations on welded products by eliminating the need of dressing or smoothing welded seams in many applications, has been announced by the Lincoln Electric Company. The new electrode, known as "Fleetweld 10", is designed particularly for finish bead welding on "U" groove welding in downhand position. The electrode provides full slag coverage and a weld deposit of exceptional smoothness. The bead is uniform and regular without square shoulders. The metal smoothes out evenly during welding and the line of fusion with the base metal is practically unnoticeable. Finish beads can be made in V-butt joints in flat position which are flush with the surface of the plates. The surface of the bead made with the electrode has much less of the "rippled" effect which characterizes the usual weld deposit.

The ability of this electrode to produce smooth welds for last-pass beads will be found advantageous in all applications where appearance is important. By employing the electrode for the final bead on joints where smooth finish is required, many manufacturers will be able to save the time and labor formerly required to dress the welds. In other cases, where the nature of the product requires grinding, buffing and polishing to assure the maximum in appearance, the finishing work will be greatly simplified as far as the welded seams are concerned. The electrode can be used with either normal or reverse polarity with direct current, or with alternating current. It is made in two sizes in 18-in. lengths, ¼ in. and 5/32 in., and is packed in 50 lb. containers as standard packages.

Dolph's INSULATING VARNISHES



. . . protect the windings of this motor-generator

This 12500 ampere, 6 volt, 6250 ampere, 12 volt electro plating motor-generator set manufactured by the Columbia Electric Manufacturing Company, Cleveland, Ohio, is protected by DOLPH'S Insulating Varnish. Here again when windings of electrical equipment are subjected to abnormal operating conditions, DOLPH'S Insulating Varnishes are chosen.

In the many departments of steel mines, too, corrosive gases attack insulation often causing premature motor failure. That is why so many steel mill maintenance men always specify DOLPH'S Insulating Varnish for all rewound or repaired electrical equipment.

Full details regarding the DOLPH Line of Insulating Varnishes for the steel industry will be mailed on request.

JOHN C. DOLPH CO.

Insulation Specialists

166A Emmett Street NEWARK, N. J.

WEIRTON ORDERS NEW STEAM TURBINE UNIT

▲ Weirton Steel Company has ordered a 10,000 kw., 3600 rpm. topping steam turbine generating unit from Allis-Chalmers Manufacturing Company for augmenting power production at Weirton, West Virginia. The complete order is said to run less than $300,000.

The unit to be constructed will be of the impulse reaction type designed for an initial steam pressure of 800 lb. gauge with a total temperature of 800 degrees F. Exhausting at 225 lb. gauge it will operate in connection with existing low pressure units. The generator will be designed for three-phase, 60 cycle, 6900 volt operation While rated 10,000 kw. at 80 per cent. power factor the unit will be good for a capacity of 12,500 kw. at 100 per cent power factor.

4 Ways to Save

1. More light from cleaner bulbs and fixtures
2. Longer life from lighting equipment
3. Lower labor cost
4. Freedom from accident

with

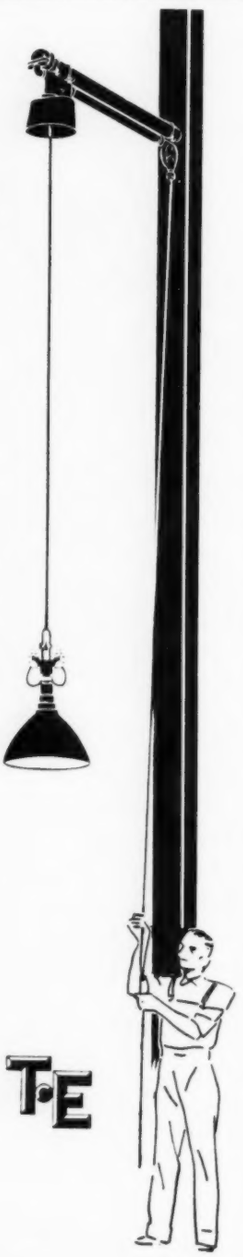
Thompson Hangers

(disconnecting . . . lamp lowering)

In practically every major industry, indoors and out, Thompson hangers are making the task of servicing high-mounted lighting fixtures easy, economical and safe. And because servicing is so simple and so inexpensive, lighting equipment is kept in better condition, which means higher lighting efficiency and longer fixture life.

More and more it is becoming standard practice to specify lamp lowering equipment for fixtures mounted higher than 12 feet.

Thompson equipment is sold through leading electrical wholesalers



T·E

THE THOMPSON ELECTRIC CO.

1101 POWER AVE., N. E. CLEVELAND, OHIO

NEW LITERATURE AVAILABLE

▲ Allis-Chalmers Manufacturing Company has published a 28-page booklet containing a vast amount of buyer's data never before available on "Lo-Maintenance Motors and Texrope Drives. The booklet is designed to present a wide range of facts that, in every industry, will help specifiers and buyers in estimating costs, types and sizes of drive equipment and motors to be used under various operating conditions.

Please write direct to Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, requesting Bulletin B-6029.

▲ Leeds and Northrup Company has prepared a catalogue describing an entirely new temperature measuring instrument called the "Leeds and Northrup Optical Pyrometer", which is a potentiometer calibrated in temperature degrees. This instrument measures temperature more conveniently, and with greater accuracy. The catalogue, which is well-illustrated, describes the instrument which is the first industrial optical pyrometer to use the potentiometer method.

Write to Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania requesting Catalogue N-33D.

▲ Amsler-Morton Company announces that a new bulletin on the subject of ingot heating is available for interested persons. It presents case history studies of six modern soaking pit installations, and a variety of information on ingot heating practice.

Engineers interested in this subject should write to the Amsler-Morton Company, Fulton Building, Pittsburgh, Pennsylvania.

▲ Colt's Patent Fire Arms Manufacturing Company has issued a catalogue describing their new "Multi-Breaker", for use in mills and industrial plants. This new breaker is a

small, compact unit for 230 volts or 115-230 volts, 2-pole or 3-pole solid neutral, that is low in cost and simple in operation. When current is broken by either short circuit or overload, a simple movement of the handle will restore the current after the cause of the interruption has been removed. The handle will not trip on a momentary overload.

No exposed live parts give absolutely safe operation, and eliminates tampering. The box can be furnished with grounded neutral, insulated (groundable) neutral, or no neutral. It is supplied for either surface or flush mounting, and is designed for 15, 20 or 25 amperes.

If you desire a copy of this new booklet, please write direct to Colt's Patent Fire Arms Manufacturing Company, Hartford, Connecticut.

▲ Farrel-BirminghamCompany,Inc., has put out a bulletin describing in detail the latest type of Farrel-Sykes gear generator for generating gears up to 25 in. diameter and explain the advantages the machine offers for high speed production of precision herringbone gears and other types of gears used for connecting parallel axes. The bulletin also describes the features of design and its precision construction which make the machine practically noiseless even when operating at high speed, at the same time enabling it to generate high precision gears rapidly and economically and to improve the accuracy of commercial gears without increasing their cost.

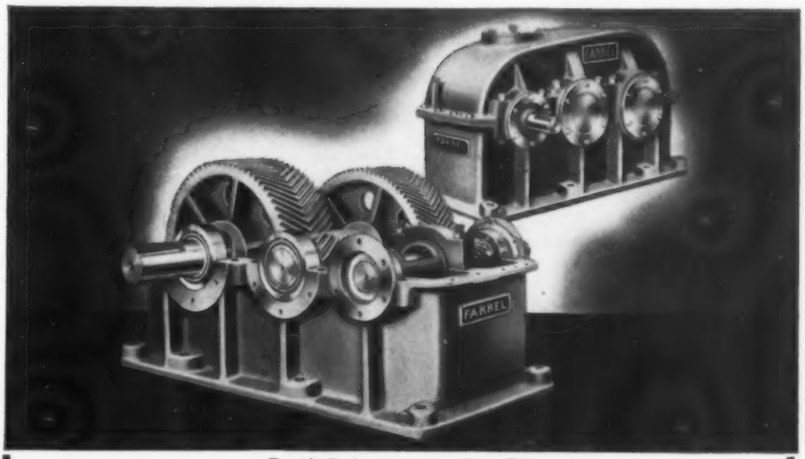
Readers desiring copies of this book should address requests to Farrel-Birmingham Company, Inc., Ansonia, Connecticut. The book is numbered Bulletin 442.

▲ Electric Storage Battery Company announces a new catalogue covering "Exide-Ironclad" batteries in motive power service. The booklet gives complete data on operating characteristics, capacities, sizes and general description of the complete line of batteries in this service.

Copies may be obtained by writing to the Motive Power Battery Department, Electric Storage Battery Company, 19th Street and Allegheny Avenue, Philadelphia, Pennsylvania.

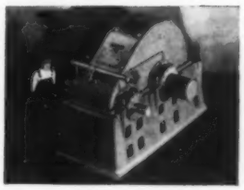
▲ Delta-Star Electric Company has published a bulletin describing a very complete line of type "M" instrument, control and auxiliary switches. The features are the unit type construction permitting assembly of any number of stages, and the flexible four-way operation, right-left or push-pull. Illustrated with seventy control diagrams, this booklet may be obtained by writing to the Delta-Star Electric Company, 2400 Fulton Street Chicago, Illinois, requesting Bulletin No. 72-D.

▲ SKF Industries, Inc., has issued a bulletin describing "Machine Tool Spindle Bearings". In its complete coverage of the entire subject of this type of bearing, the book uses diagrams and pertinent data on dimensions. The "Double Row Cylindrical Roller Bearing" and its many features, used in conjunction with other bearings in typical mountings. are also described in the book. Copies may be obtained by writing to SKF Industries, Inc., Front Street and Erie Avenue, Philadelphia, Pennsylvania.



Double Reduction Unit—Type DR

FARREL GEAR UNITS



Farrel Heavy Duty Mill Drives are ruggedly built to withstand the stresses, shocks and wear encountered in modern mill practice.

Send for Catalog No. 438 giving complete descriptions, specifications, ratings and dimensions.

Excel in Uniform, Silent and Positive Power Transmission

Farrel Gear Units are noted for smooth, quiet operation and dependable performance under all conditions. This is due to their precision generated continuous tooth herringbone gears, famous for extra strength and durability; to accurate mounting of shafts in anti-friction roller bearings and to heavy cases, strong and rigid enough to prevent deflection and vibration.

Farrel Gear Units have been developed in a complete line for all types of applications and service conditions. Designs include single, double and triple reduction units, speed change units with two or more selective speeds, speed increasing units, right angle units and special drives to meet special requirements. All types and sizes are totally enclosed and self-contained. They are standardized in general design, but with flexibility in detail which permits variation to suit specific conditions of speed, load and service.

FARREL-BIRMINGHAM COMPANY, INC.
366 VULCAN STREET BUFFALO, N. Y.

FARREL SYKES GEARS — *The Gear with a Backbone*

ITEMS OF INTEREST

H. E. Beane field sales manager of the Bristol Company, Waterbury, Connecticut, is spending several weeks visiting steel plants on the Pacific Coast to study conditions in order to further improve service customers in this territory. In this connection, the Bristol Company has developed a speed coordinated central system especially adapted for use in steel plants on open hearth, soaking pits and other mill operations.

The Bristol Company is represented on the Pacific Coast by R. G. Tower, district manager, with offices and a branch factory and service laboratory being maintained in the Rialto Building, San Franscisco. Under Mr. Tower's jurisdiction, the Bristol Company operates a branch office in the White Building, Seattle, with W. J. Peckham in charge; and in the Warehouse Building, Los Angeles, with W. R. Rogers in charge.

B. H. Lawrence formerly chief engineer, has been elected vice-president in charge of engineering for the United States Steel Corporation of Delaware, and a member of its executive committee and board of directors.

With the exception of three years immediately following his graduation from college, Mr. Lawrence has been connected with United States Steel subsidiaries during his entire engineering background. He has served in executive engineering capacities in the Chicago, Illinois; Worcester, Massachusetts; and Cleveland, Ohio districts. He has been chief engineer of the United States Steel Corporation of Delaware since January 1, 1938.

H. E. BEANE

H. V. Lauer has been appointed superintendent of the Joliet coke plant of the Carnegie-Illinois Steel Corporation. He was formerly assistant superintendent of the corporation's Gary Works coke plant. Mr. Lauer was first employed at the Gary Works in August, 1935, as a practice engineer. A year later he was made assistant superintendent of the coke plant there and served in this capacity until the present time. He was formerly employed by the General Refractories Company, Union Carbide Company, and the Wisconsin Steel Company.

Marion G. Crosthwait was appointed assistant superintendent of the wire works of the Tennessee Coal, Iron and Railroad Company, Fairfield, Alabama. Mr. Crosthwait was born December 18, 1896, in Birmingham, and was educated in local grade and high schools and studied mechanical engineering at Alabama Polytechnic Institute. His career with the United States Steel Corporation began in March, 1920, when he was employed as a draftsman in the Fairfield plant of the American Steel and Wire Company. In January, 1923 he was promoted to head draftsman, and held this position after the transfer of the wire plant to the Tennessee Coal, Iron and Railroad Company in February, 1933, and until this recent promotion.

C. F. Reilly has recently been appointed Pittsburgh district manager of the D. B. Flower Manufacturing Company, and the General Devices and Fittings Company, succeeding the late J. H. (Jerry) Albrecht. Headquarters will continue to be maintained at 614 Empire Building, Pittsburgh, Pennsylvania.

John P. Hoelzel formerly vice-president and general sales manager of the Pittsburgh Screw and Bolt Manufacturing Company, has been elected as president. This company which is located in the Pittsburgh area, also owns and directs the activities of the Colona Manufacturing Company of Monaca, Pennsylvania.

Ralph E. Hough has been made general manager of the Cambria plant of the Bethlehem Steel Company in Johnstown, Pennsylvania, succeeding the late C. R. Ellicott. Mr. Hough entered the steel business in 1905 with the Lackawanna Steel Company, and when that company was taken over by Bethlehem in 1922, he was named superintendent of the bar mills at Lackawanna. He was transferred to the Cambria plant in 1928 as superintendent of the Gautier mills, and was made assistant general manager in August, 1936, holding that position until his recent appointment.

RALPH E. HOUGH

Obituary

J. MORRIS IRELAND

J. Morris Ireland 54, special representative for the Westinghouse Electric and Manufacturing Company, recently died. Mr. Ireland was born in a small community near Baltimore, and went to Cleveland, Ohio, in 1911 joining the Westinghouse organization. In 1926 he became manager of the company's sales office in that district, and in 1931 was appointed to the position he held at his death. Mr. Ireland was an Associate Member of the Association of Iron and Steel Engineers since 1914, being greatly interested in all the varied activities of the society. He was also active in the Electrical League of Cleveland, of which he was a former vice-president.

Avery C. Adams has been elected vice-president in charge of sales for the United States Steel Corporation of Delaware, at the same time becoming a member of the executive committee and board of directors. Mr. Adams, who began his business career in a Youngstown steel mill, specialized in metallurgy before entering sales work. He first joined the United States Steel subsidiaries in 1936 as manager of sales, sheet division, Carnegie-Illinois Steel Corporation, after serving as a sales executive with Trumbull Steel Company, Republic Steel Corporation, and General Fireproofing Company. From December 1, 1938 until his election to his new office, he was vice-president and assistant general manager of sales for Inland Steel Company.

Mayo D. Hersey recently joined the staff of the Morgan Construction Company as research director, with offices at Worcester, Massachusetts. Mr. Hersey was for fifteen years connected with the National Bureau of Standards at Washington, D. C. He served as associate professor of properties of matter at the Massachusetts Institute of Technology, also as physicist in charge of the physical laboratory at the Pittsburgh Experiment Station, United States Bureau of Mines, and more recently as head of the test department in the Kingsbury Machine Works, Inc., at Philadelphia.

Super-Sensitive

THE HAYS "OT" DRAFT RECORDER

For Soaking Pits, Annealing Furnaces, Open Hearth Furnaces, Slab Mills, Dry Kilns, Filters . . . wherever an accurate record of draft pressure or differential is desired

GOOD STEEL PRACTICE today demands very accurate control of furnace operation.

Here the HAYS Series "OT" Supersensitive Draft Recorders perform an invaluable service by providing that knowledge of furnace conditions so essential to control.

These HAYS instruments accurately record draft, pressure or differentials of air or gases in ranges from .1 inch water to 100 inch water (total range).

Instrument cases are of either cast iron or aluminum—to resist corrosion in different atmospheres. HAYS "OT" Recorders are built husky enough to withstand dirt-laden air and severe operating conditions yet sensitive enough to register accurately increments of .0025 of an inch water. They are built to meet your particular operating requirements. Write to 955 Eighth Avenue, Michigan City, Indiana, for more detailed information.

The HAYS CORPORATION

SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL

MICHIGAN CITY, INDIANA, U.S.A.

One Mill Saved **87%** *with a*

● Handling heavier loads with greater ease and speed, the Baker Articulated Sheet Handler reduces costs — one mill reporting as much as 87% savings. Packages weighing ten tons, and sizes up to 48" x 144" are taken through box car doors, carefully loaded, one in each corner and one shorter package in the door space — with savings not only in time and labor, but in protection of sheets from damage as well. Illustration shows this truck with a wrapped package of finished auto-body sheets — on which the manufacturer will save on finishing expense — thanks to careful handling.

The Baker Material Handling Engineer can show you similar savings in your plant.

BAKER INDUSTRIAL TRUCK DIVISION
of the Baker-Raulang Company
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